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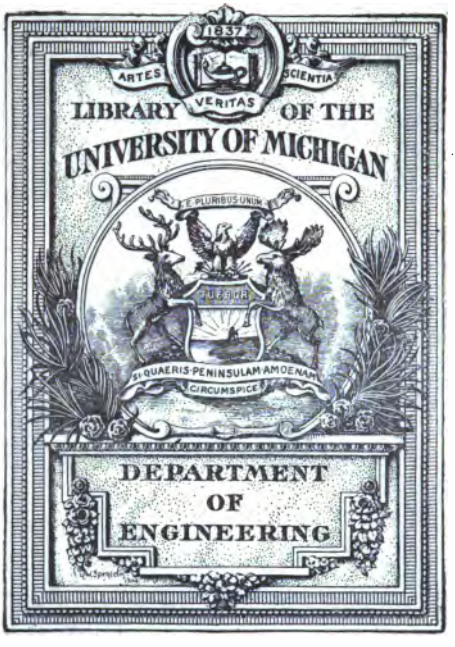
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THE PROFESSOR ON SHIPBOARD

A STORY OF A VOYAGE OF A COLLEGE PROFESSOR WITH HIS BROTHER WHO WAS CHIEF ENGINEER OF A STEAMSHIP

BY

C. A. McALLISTER

Chief Engineer, U. S. Revenue Cutter Service

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IV.

PREFACE.

Many practical men will read a story but steer clear of a serious article which may, perhaps, cover the same subject. It was to reach just such men that the following story was written.

The purpose has been to give as much practical and useful information as possible regarding the handling and care of boilers and marine engines, and yet have story enough to hold the interest of the reader.

So many letters of inquiry have been received, asking for further information on many points, that it is evident the story has been carefully read, and it is because of this apparent interest that "THE PROFESSOR ON SHIPBOARD" is now published in book form.

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CHAPTER I.

IN THE FIRE-ROOM.

The Professor was a man of small stature, slightly stoop shouldered, somewhat cadaverous, wore glasses, but withal carried a general air of intelligence and good nature. After graduating from college at the head of his class, he had been employed for several years as an engine draftsman at a large shipbuilding establishment, where he became very proficient in the theoretical side of marine engineering. A vacancy finally occurred in the chair of engineering in his college, and he was tendered the position. This he gladly accepted, as being more to his liking than the hustle and worry incident to a billet at a progressive shipyard.

Having now more leisure at his command he devoted considerable time to the preparation of essays to be read before engineering societies, and finally became the author of a treatise on his favorite branch, marine engineering. In this way his name became prominent in the profession, and he was looked upon as more or less of an authority by men interested in the business.

The Professor had an older brother, who was, in every particular, as different from his younger relative as two men can be. In his youth he was stout and robust, fond of all outdoor amusements, and very early in his career developed a fondness for the water. To him, going to school was looked upon as a sort of imprisonment, and his abhorrence for books was very pronounced. His father pleaded with and threatened him, but all to no avail. His mind was set on going to sea, and nothing else would do. Finally he was taken out of the public school, much to his delight, and yielding to his father's advice he started in as an apprentice in a large

machine shop, with the ultimate intention of going to sea as an engineer.

Being naturally apt in learning anything in which he was interested, he rapidly picked up a good knowledge of the trade, and at the end of his apprenticeship was looked upon as a first-class machinist.

He soon found employment on a large coastwise steamship as a fireman. Being very attentive to his duties and a sober young man, it was not long before he was advanced to an oiler's position. A vacancy occurring by the death of an old chief engineer, and the young man having by this time sufficient experience, he obtained a license as third assistant, and was given that position on another of the company's steamers. After ten or twelve years of faithful service as a licensed engineer he was advanced until he became the chief engineer of one of the most modern vessels of the line.

He was very fond of his younger brother, the professor, but on such occasions as they met he could not refrain from poking fun at him, in a good natured way, on account of what he termed his "foolish booktalk." Many were the friendly arguments they held on various topics connected with marine machinery, each of course presenting his own side of the case. One of the chief's favorite taunts to his learned brother was that he would not know how to get a vessel's engine under way, even if he did know all about designing it. As a matter of fact this lack was the professor's weakest point. True, he had made several voyages across the Atlantic on fast passenger ships, and had once been a guest on board a United States battleship during her official trial trip. Finally, at the urgent invitation of his sea-going brother, he decided to take a trip with him on his vessel, which was soon to sail for a South American port. The chief told him that he could spend as much time in the engine and fire rooms

as he wished and that, if he thought he could make any improvements he was welcome to make suggestions to the men.

The Professor, who was then on his annual vacation, decided to make the trip as instructive as possible, and being very thorough in everything he undertook, he made all necessary preparations to spend considerable time below the gratings. To his other clothing he added three suits of overalls and a cap, and on the morning of sailing day he came aboard the ship seemingly prepared for any emergency. He was, of course, welcomed by his brother, assigned to a pleasant stateroom on the upper deck, and introduced to the other officers.

The ship left New York promptly at the appointed time, and was soon steaming past Sandy Hook on her way to the southward. As the sea was smooth the Professor decided to begin his investigations on marine engineering afloat, and made up his mind to spend the first day or so in the fire room, thinking that the proper place to begin. He finally put in an appearance, clad in a suit of overalls, redolent with the smell of dye-stuffs, and fitting him like a bag on a beanpole. The Chief was not around at the time, so the book man slowly descended the slippery steps to the lower engine room and groped his way to the fire room, arriving there just as the 4 to 8 watch was coming on. The watch consisted of a water tender, four firemen and two coal passers, known technically as "snipes." They gazed with astonishment as the spare form of the Professor emerged into the fireroom, and nudged each other knowingly, while one brawny fireman, who had not recovered from the effects of the water front whiskey he had imbibed before sailing, shouted out derisively, "Git onto his goglets!"

This ejaculation created a laugh at the Professor's

expense, which, however, was rapidly followed by silence as the hustling second assistant, who had charge of the watch, came into the fireroom and told all hands that the Professor was the Chief's brother, and that he must be respected accordingly. Being now assured that the men knew who he was, the college man proceeded to look about him with a critical eye. The first thing that attracted his attention was the act of a fireman who opened one of the furnace doors and proceeded leisurely to fill up the furnace to the very top with coal, after which he sat down, filled his pipe, and began smoking. This seemed to shock the Professor's ideas on combustion, so he explained to the man that it would be much better to carry his fires 8 or 10 inches deep, in order to secure more perfect combustion, and wound up his remarks by saying, "Always carry your fires parallel, and not too deep." This brought forth the inquiry, "What the divil does 'parel-eel' mean, Sor?" The Professor explained to him that they should be of the same depth for the whole length of the furnace, and at the same time concluded to use no more mathematical or scientific terms around that fireroom. While he was on his subject he explained to the men that the practice of carrying "crown sheeters" was a very bad one. While no doubt it saved the firemen work by not being compelled to charge the furnaces at such frequent intervals, it filled the furnaces to such an extent as to prevent the proper mixture of air and gases, and consequently the boilers would not steam nearly so well as they would if light fires were carried and the slice bars used more frequently. At this point he noticed three of the firemen open the doors of different furnaces and begin charging them at the same time. After they were through he called their attention to this as being very bad practice, explaining that this rush of cold air into three different boilers at the

same instant had a very bad effect on the production of steam, and told them that in the future they should arrange to fire each furnace separately, and to work very quickly, so as to keep the doors open as brief a time as possible.

A little later, noticing a large accumulation of ashes in one of the ash pans, he directed one of the coal passers to haul them out and put them in a pile in an out-of-the way place, at the same time explaining that if ashes were allowed to accumulate in that manner it hindered the free access of the air through the grate bars, thus preventing the fires from burning as they should, and at the same time incurring the danger of overheating the grate bars. While one of the furnace doors was open he had the opportunity of observing the spacing of the graet bars, and, much to his surprise, found that the air spaces were very much cramped. He made a mental note of this and determined to recommend that new bars be fitted with air spaces not less than 40 per cent of the total grate surface. He also saw at a glance that the bridge walls were too high, and prevented to a certain extent the free flow of the gases from the furnaces. This he determined could be remedied by putting in new bridge walls with their tops slightly crowned, and having a clear area between the crown of the furnace and top of bridge wall of about 16 per cent of the grate area.

While thus soliloquizing he was suddenly brought to a realization of his surroundings by a noise like a shot from a gun, and immediately thereafter he became deluged with a shower of scalding water. Not knowing what had broken loose, and being completely terror-stricken, he made a dash for the door, falling over a coal scoop and landing on a pile of coal in his flight. These antics caused a roar of laughter among the men, and looking around he saw the water tender

climbing up on the grating with his head and hands covered with old bagging. The cause of the commotion was the breaking of a gauge glass directly over where the Professor had been standing. The automatic valves in the pipes had failed to work promptly, but the stop valves were shut off quickly by the water tender, with whom such matters were of frequent occurrence.

The Professor had not learned of such incidents in his books, and he could not help admiring the readiness and bravery displayed by the water tender in climbing up on the grating in the terrific heat, and putting in a new glass almost before he himself had recovered from the shock the outbreak gave him. Being somewhat unnerved by his fright from the explosion, and smarting from the effects of the hot water, the Professor decided to postpone further investigation for that day. As he gazed in the mirror in his room and saw his smoke-begrimed features reeking with perspiration, he made up his mind that there was a decidedly unpleasant side to marine engineering, to which he had just had a slight introduction. He determined, however, to again visit the fireroom on the following day, but inwardly resolved to keep away from the vicinity of water gauge glasses. The Chief looked in on him for a few minutes, and was convulsed with laughter at the woe-begone appearance of his brother. The Professor's mental discomfort was not at all relieved by the remark, "Oh! you are getting off easy today. Wait until you stand a watch in a gale of wind!"

CHAPTER II.

HARDSHIPS OF FIREMEN.

After the Professor had washed up and changed his clothes that evening he went to dinner, where he was introduced to some of the passengers. Dinner being over, they all adjourned to the upper deck and sat around engaged in conversation until four bells struck, when the Professor, feeling rather tired from his first day's experiences, decided to "turn in." The evening was cool, there being a light air blowing and a gentle swell, and as he rolled up in his blanket he concluded that going to sea had some pleasant features after all.

The next morning he was called early; getting up at once and dressing, he went out on deck and found the weather conditions about as they were the night before. The salt air had given him a good appetite, and after a hearty breakfast he went to his room, donned his overalls, and at 8.30 was ready for another day of observations below. Going at once to the fireroom he found an entirely different lot of men on watch from those he had met the afternoon before. However, all hands had heard that the chief's brother was on board, so there was no surprise expressed when he came in and introduced himself to the water tender. He gazed respectfully up at the gauge glass which had broken the day before, and as he walked around the fireroom, gave it a wide berth. A big, brawny fireman was cleaning a fire in one of the port boilers, and the Professor could not but look with admiration at the fortitude of the man as he wielded a heavy slice bar and gazed fearlessly in at the white hot clinkers which he was prying off the bars. The heat was so intense that the Professor could scarcely believe that a human being could endure it, let alone performing the hardest kind of

work under its fiery glare. This led the Professor to soliloquize on the difficulties that would be encountered in adapting mechanical stokers for marine work. Considering the suffering that firemen now have to undergo, he wondered that more attention was not given to this important matter by inventors.

After the fire had been cleaned and filled up with fresh coal the man, almost exhausted, sat down on a bucket under the mouth of the ventilator. The Professor stepped up to him and expressed his sympathy, but was greatly surprised to hear the fireman reply: "Ah! dat aint nothing, wait till we get down in the tropics, where it's hot for sure." And this for forty dollars a month, thought the Professor. How can they get men to do it?

His attention was next called to a grimy looking individual who was puffing and sweating as he shoved a large bucket of coal suspended from a trolley over head, through the bunker door and dumped its contents on the fireroom floor. After the man had gone back into the bunker the Professor, somewhat timidly, started in to see where he had gone. As he stepped through the bunker door he found himself in absolute and dense darkness, and as the bunker he was in was right alongside of the boilers, the heat was, of course, intense. Added to this the air was filled with a stifling coal dust. After becoming somewhat accustomed to the darkness he saw at what seemed a great distance off, a faint, flickering light. Groping his way along and stumbling over lumps of coal he finally reached the after end of the bunker, where he found the coal passer diligently shoveling coal into the bucket and whistling away as if his was the happiest lot on earth. The man was so black that he could scarcely be discerned from the surrounding pall of darkness; to add to the dust the petticoat lamp suspended from a

beam overhead was emitting clouds of vile smoke from the lard oil which it was burning. The Professor asked the coal passer how he could live and work in such a stifling atmosphere. He was again greatly surprised at the rather cheerful answer that "This is dead easy to what it will be when it gets rough and I have to push coal out of the 'thwartship bunkers." Well, thought the Professor, human happiness is, after all, only a matter of comparison. His lungs having by this time become, as he thought, about filled with coal dust, he made a hasty exit, and found the fireroom much more habitable than it seemed before he went into the coal bunker. This experience set the Professor to reasoning why ship designers could not arrange coal bunkers so that they would be more accessible, or so that a good proportion of the coal would, by the force of gravity, run into the fireroom. He could also see no good reason why ventilating pipes should not be fitted to coal bunkers, which would not only help to carry off the smothering coal dust, but would at the same time tend to lessen the danger of spontaneous combustion. Another improvement which he thought should be made was to install heavily protected incandescent bunker lights, or arrange for portable lights, and thus do away with the loathsome smoke from oil lamps. Such improvements would add slightly to the first cost, but taking into consideration the decreased hardships on the men, he concluded that it ought to pay in the quicker and better work which would result. It was gradually dawning on the scientific man that ship designers are too often men who are so absorbed in theories that they seem to lose sight of the fact that the success of the ships and machinery of their creation depends as much or more upon the men who run them, than it does upon the excellence of the design in itself. With this thought in mind he concluded that in-

creased attention ought to be given to making things more comfortable for these "toilers of the deep."

At this point a shrill whistle somewhat startled the Professor, and as he turned around quickly he saw the water tender rush over to the engine room speaking tube and shout: "Aye, aye, sir!" What was said by the engineer of the watch could not be heard by any one except the water tender, but there was a faint suspicion of blue air around the mouthpiece, after the water tender had left it, and made a dive for the check valve on the after boilers. This haste on the part of the "boss of the fireroom," and the dull thumping sounds coming from the engine roon caused the Professor to look anxiously about. Looking up at the water gauge glasses on the two after boilers he saw that the water was away up to the top, while on the forward boilers there was only two or three inches of water at the bottom of the glasses. The water tender had been in a trance; as a result of the high water the after boilers had foamed, and the water being carried over with the steam, had caused the hammering in the cylinders, much to the disgust of the first assistant on watch. With the after-checks shut off and all the feed put on the forward boilers, the water soon resumed its normal level in all four boilers, and the foaming ceased. Although the water had been too high in the after gauge glasses, the Professor could see no reason for the foaming until he noticed the position of the glass relative to the diameter of the boiler. He saw at a glance that whoever had designed the boilers had fallen into the common error of robbing the steam-room to gain heating surface. His brother, the chief, came into the fireroom at this time, and, figuratively speaking, jumped onto the poor water tender with both feet. Turning to the Professor, he said: "Well, how do *you* account for this foaming?" This gave the Professor

an opportunity to explain that the boilers did not have sufficient steam room, and that the foaming was due more to that fact than to the carelessness of the water tender. Continuing, he said that boilers should have steam space sufficient to give a "life of steam" of not less than twenty-five seconds. As this seemed too abstruse a statement, he continued by saying that a good rule of thumb was never to have the highest heating surface much less than one-third of the diameter from the top of the boiler. "That may be so," said the chief, "as the highest heating surface in these boilers is much nearer the top than that." Muttering to himself, and with a warning glance at the water tender, the chief then went aft and left the Professor to his further observations.

He had been keeping an eye on the water tender for some time, but had not observed him try the gauge cocks, although he, of course, looked at the glass gauges quite frequently. He finally asked him why he did not try the gauge cocks occasionally as a check on the water level shown in the glasses. He was answered rather shortly: "They won't work." Upon closer examination he saw that they were of the screw pattern, and that they were fitted with long rods which actuated the gauge cocks by means of bevel gear wheels. The Professor tried to open one, but could not budge it. The water tender explained to him that they had not been used for months, and that even when they were thoroughly overhauled it was very difficult to operate them. This somewhat astonished the Professor to think that the gauge glasses had been alone depended on, and he did not hesitate to tell the man that it was very dangerous to rely on one method only of ascertaining the water level. He also told him that, in his opinion gauge cocks should be made as simple as possible, and that the ordinary weighted cocks, such as is

used on stationary boilers, would be more reliable, as they are bound to work by simply raising the weights with a forked rod.

As the boilers were not steaming very well, the engineer ordered the water tender to have the tubes of one of the after-boilers swept. The connection doors were raised, and one man proceeded leisurely to blow out the tubes with the steam tube cleaner. He went at it so slowly that the Professor spoke to the water tender to hurry the man, and explained that keeping the connection doors open so long not only kept the steam down, but the rush of cold air on the hot tube sheets was very bad and might start the tube ends leaking. He said that this was such an important matter that it seemed to him that two tube cleaners should be fitted and then have two men put on one nest of tubes at a time, in order to keep the doors open as short a time as possible. The operation of slicing the fires next absorbed the Professor's attention, and the way the men wielded the heavy slice bars excited his admiration. He could now readily see how useless it is to make the grates over six feet in length, as he observed that it took a strong man to shake up the backs of even a six-foot fire. In slicing the fires he noticed that the men put the slice bar through the small doors provided for that purpose in the furnace doors. Even if the furnace doors were opened, however, he could see that it was impossible to work the corners of the fires alongside of the furnace fronts. He concluded that it would be a good idea to fit slice bar doors or flaps at the level of the grate bars in each side of the furnace front, so that the corners of the fire could be properly sliced.

It was now six bells, and word was received from the engine room to hoist ashes. The men went at it in the old-fashioned way; one of the firemen was sent on

deck to run the ash hoister, three men were detailed from the deck force to dump the buckets into the ash shute, and below it took all hands except the water tender to shovel the ashes under the ventilator and to fill the buckets. It took fully fifteen minutes to get out the ashes in this manner, and the Professor remarked to the water tender that he had seen trials with an ash ejector where three men had put out the same amount of ashes in half the time. Taking into consideration the fact that as everybody was engaged in handling ashes, and consequently could not work the fires, and the amount of steam used by the hoisting engine, the Professor was of the opinion that the extra amount of steam used by the pump connected with the ejector would be more than compensated for by the use of this modern appliance.

"Something is burning!" suddenly shouted one of the firemen, and sure enough there was. As the Professor had become so absorbed in his reverie over ash ejectors, he did not notice that he was standing on a hot slice bar until half of the sole on one of his shoes had been ruined, and a large blister raised on the bottom of his foot. The Professor concluded that it was about time to look at his watch, and to his surprise, he found that it was nearly noon. As he had been below nearly an entire watch he thought he had acquired enough experience for one day, and so limped out of the fireroom and went on deck. As he was slowly washing the coal dust out of his hair, eyes, nose and ears, he ruminated over the fact that practical experience, gained by a scalded neck one day and a burned foot the next, not to mention a ruined shoe, was harder to obtain than knowledge from books.

CHAPTER III.

NIGHT WATCH IN A GALE.

The following morning the Professor got up just before breakfast time, but he was not feeling quite as well as usual. The fact of the matter was that his experience of the previous day had tired him out. After breakfasting he made up his mind to rest all day on deck and if he felt any better he thought he would try a night watch in the fireroom, as he had determined to spend some further time around the boilers.

Having brought some books with him, he managed to while away the morning hours very well by sitting on a steamer chair in the shade of an awning and reading. In the afternoon he took a short nap in a hammock, and afterwards spent several hours very pleasantly talking with some of the passengers. During his conversation he fell to discussing the running of steamships in a general way, and was greatly surprised to learn how little the average sea traveler knows of how ships are run. The majority of them seemed to look upon the engineer's force as a kind of necessary evil, and were very prone to give the entire credit for the safety of the vessel, etc., to the well dressed deck officers who after standing a watch on the bridge, spent their spare time in gossiping around among the passengers. The Professor proceeded to enlighten them upon the vast responsibilities heaped upon the workers in the engine and fire rooms.

"Why," said he, "if you could but realize it, your very lives are constantly at the mercy of those men down below there. Suppose that one of the water tenders should be negligent of his duties and allow

the water to get below the danger point in the boilers. Well! you would never be able to collect the pieces."

He likened the four boilers to a magazine containing a large quantity of dynamite—perfectly harmless so long as they are taken care of, but if they ever explode, it is all over with the ship. Continuing, he said:

"You who travel by steamer may never know how much your safety depends upon those grimy looking individuals whom you see crawling out of the fireroom hatch, but at the end of this voyage if you have any praises or thanks to offer for a safe journey, remember that a large portion of it is due those suffering men below, where you passengers never visit."

Towards evening the first heavy clouds of the trip were seen away on the horizon. The first officer remarked that the barometer had been falling and that they would probably encounter some dirty weather before morning. This was not particularly cheerful news to the Professor, and he turned in shortly after sundown resolving to spend the mid watch below.

He had seemingly been asleep only about an hour when a sharp rapping came at the door of his stateroom, and a harsh voice announcing that it was a quarter to twelve, was heard on the outside. As the college man gradually opened his eyes and regained his consciousness it dawned upon him that something unusual was occurring. His watch which he had hung on a hook was swinging from side to side; his shoes were having a hurdle race to and fro on the floor, and as he attempted to rise an unusually severe lurch of the vessel rolled him out of his bunk on the floor, and as he attempted to rise, an unusually severe wind through the rigging could be heard and the mournful sounds thus produced struck terror to the Professor's heart. His first impulse was to crawl

back into his bunk, but he finally made up his mind to see it through and make the best of it.

After a great deal of difficulty he succeeded in getting into his clothes, and half struggling along he groped his way to the engine room. Standing on the upper engine room grating and grasping a hand rail he gradually came to the realization of what was before him. To add to his discomfort he began to feel the first qualms of sea sickness. He again almost decided to retrace his steps, but just at that moment the second assistant engineer came up and in a cheery voice said: "Good morning, Professor. Now you will have a chance to see how we run things during a gale of wind." It was too late then to go back, and with a forced smile he said: "I don't see how you manage to stand on your feet, let alone do any work." The fact that the second assistant was vigorously puffing away on a large black pipe and blowing the smoke towards the Professor did not add the least to his comfort. By a strong effort of the will, however, he made a dash over to the engine room ladder and slowly began to descend the steps. One moment he felt like a fly walking on a ceiling and the next he seemed to be walking on a horizontal ladder, but he managed to hold on until within about four steps of the floor plates in the lower engine room. At this juncture his feet slipped off the oily steps and losing his grip on the hand rail he fell sprawling on the floor. An oiler seeing his plight ran over to him and assisted him to get on his feet again, remarking at the same time, "I hope you are not hurt, sir." Upon regaining his breath he replied that he was more scared than hurt. Feeling somewhat rattled by his hasty descent, he managed to crawl over to a seat where, by locking his arms around a convenient stanchion he was able to keep his position. The fear-

ful rolls and plunges of the vessel were not felt so badly in the lower engine room, but, nevertheless, walking about was accomplished only by taking advantage of the brief intervals when the ship was on an even keel and then hanging on to some convenient stanchion, pipe or other fixture. The oiler, who had spent many a weary watch under just such conditions, went about his work, now feeling a crank pin with one hand while holding on with the other, and again vigorously working a squirt can into some cup or oil hole. Apparently he cared nothing about how badly the ship was lurching. Such nonchalance filled the Professor with amazement, and he wondered how many trips he would have to make before he could get about with such apparent ease. With the intention of making his engine room observations on some other day he reluctantly left his safe perch and half walking and half crawling made his way to the fireroom. Just as he stepped in, greatly to his horror, he found he was standing in water half way up to his knees. As the vessel rolled over to the other side there was the sound of rushing water, and he noticed that the opposite side of the fire room floor was inundated. Visions of a sinking ship flashed across his mind, and he mentally calculated how long it would take for the water to reach and extinguish the fires. Noticing that the men did not seem at all excited, he made his way over to one of them and in a trembling voice inquired if the ship was sinking. "Oh, no, sir; don't be afraid—there is nothing the matter except that the strainer on the end of the suction pipe is plugged up. Callahan is cleaning it out now, and we will soon have this water out of her." Looking down between the after boilers he saw a big brawny fireman standing in water up to his waist, and as opportunity offered reaching down and pulling up handfuls of coal, ashes,

and occasionally small lumps of waste. After a great deal of effort the strainer, one of the ordinary box variety, was cleared out, and before long the welcome sound of sucking mixed air and water was heard at the strainer, thus indicating that the bilges were free. Cleaning out the strainer under such conditions seemed to the Professor as little less than barbarous, and he wondered why designers did not fit all suction pipes with Macomb strainers placed above the floor plates where they would be easy of access for cleaning out.

Placing himself in an out of the way corner, where he had a good place to hang on, he decided to remain there and look about. His attention was naturally attracted to the gauge glasses, and he hoped that none of them would blow out again while he was in the fire room. The way the water was dancing up and down somewhat startled him. One instant the glass would be filled over the top and the next it would go out of sight at the bottom. Each glass was on the inboard side of its boiler, and naturally the fluctuation of the water level was very great at each roll. This arrangement seemed to the Professor rather uncalled for, as he could see no objection to having the glass right opposite the center of each boiler, where the water would naturally be quieter than on either side. Remembering his conversation with the water tender on the previous day, he concluded that if the men could not be made to use the gauge cocks, an ideal arrangement would be to have two separate gauge glasses, each with independent pipe connections, and both arranged at the center of the boiler in such manner, of course, that they would be clear of the connection door.

He observed with some satisfaction that the firemen were following his advice in not charging more than one furnace at a time. He was, however, sur-

prised to see that it took one man to hold a door open while another one was shoveling in the coal. He didn't think it possible that any man would get up furnace fittings in these days without having catches fitted to hold the doors open when firing in a heavy seaway.

His attention was next attracted to the steam gauges, as no two of them showed the same pressure. The after port boiler gauge registered 155 pounds, while its mate showed only 150 pounds pressure. He asked the water tender if the gauges had ever been tested and was informed that they had not been tested since he joined the vessel. He further remarked that he had some fun with a green fireman on a previous trip. The greenhorn had the boiler with the low gauge on it, and he nearly worked himself to death trying to get his steam up to the pressure shown on the opposite gauge. The Professor remarked that he thought that every ship should have a standard test gauge on board, and that all gauges should be regulated at least once in three months. In this connection he said that all springs were unreliable, and that the only proper gauge tester would be one that used actual weights for the purpose of comparison. Noticing that the water tender when manipulating the feed checks had to go around to the sides of the boilers, he asked him if he did not think it was rather inconvenient. The water tender said it would be much better to have them on the fronts of the boilers, and said that he wished the draughtsman who had arranged these checks could be there and have to tend water himself. He also suggested to the Professor that it would be better to have the main check on one side of the front and the auxiliary check on the other side, as it would save confusion when breaking in a new man. While on this subject he called the Pro-

fessor's attention to the temperature of the feed water. Upon investigation he found that he could easily bear his hand on the check valves. The Professor remarked that he did not believe the feed water was entering the boiler at a temperature of more than 130 degrees. "There is one of the results of it," he said, pointing to a spot on the seam of the lower head which was covered with salt and bubbling. "The other result will be found in the coal bill. I wonder how long it will be before ship owners will realize that feed water heaters will pay for themselves in six months' time. By the way," he said, "I notice that you don't tally up the coal you use." "Oh! that is too much bother," said the water tender.

"It wouldn't be much bother," said the Professor, "if you had a counter near the desk in the engine room and make the coal passers register each bucket of coal they dump in the fireroom, by simply pulling a wire connection each time. You could then keep an accurate account of the amount of coal you are using."

"Where are your bottom blow valves located," next inquired the visitor. In answer to this the water tender tapped his foot on the floor plates, indicating thereby that they were underneath the floor. "That is an old fashioned idea," remarked the Professor. "It seems to me that they would be much more convenient if they were brought up on the side where they can be gotten at without raising a floor plate. They can just as well be bolted to the shell higher up and be connected to an internal pipe leading down to the lowest part of the boiler."

Continuing his questioning, he asked if there was any gear for raising the safety valves in case of necessity. He was shown a screw gearing secured to the bulkheads at the sides in an almost inaccessible place.

The threads of the screws were rusty in appearance and looked as if they had never been used since they were put in place. He said to the water tender, "You ought to keep that gearing well oiled and ready for use—some day you will want to get at it in a hurry and you will find that you can't turn that hand wheel with a yoke of oxen."

The Professor by this time thought that he must have been in the fire room for at least four hours, but was disappointed upon consulting his time piece to find that it was only half past one. He began to feel very weak in his stomach, as the rolling had increased considerably since he came below. He began to wish he was on shore where he could walk without using his hands as much as his feet. In fact he was beginning to realize keenly some of the discomforts of a seafaring life. No one who has not had the actual experience can realize what it is to be called at midnight from a sound sleep, get up and dress and go into a hot engine or fire room and at once, before being quite awake, assume the responsibilities of keeping things moving, no matter how hard a gale is blowing or how rough the sea. The time from midnight until 4 A. M. under such circumstances drags along until one feels that a month must have passed before his relief appears. The Professor on this occasion did not wait until the watch was over, but had enough of mid watches by 2 A. M. and managed to get his clothes off and crawl into his bunk, where he spent the remainder of the night trying to keep from rolling out on the floor, and in retaining his dinner of the previous evening.

CHAPTER IV.

INTERVIEW WITH BARNEY THE OILER.

Although the Professor was tired out from his exertions below during the mid watch, he was unable to sleep after he got in his berth. It was simply a case of "hang on" for the rest of the night. He managed by considerable ingenuity to arrange a sort of bulkhead out of the pillows and a blanket, which prevented his being rolled out on the floor. Finally overcome by fatigue he fell into a series of cat naps, broken at intervals by sudden awakenings due to unusually heavy seas striking the vessel. When daylight came he did not feel like arising, so he occupied his bunk the entire morning. Just before noon, finding it impossible to gain any rest or sleep in bed, he got up and dressed with great difficulty. The thought then occurred to him whether his companions below who had worked the entire mid watch, felt any better than he did, and if they did not, how it would be possible for them to put in another watch. He went into the main saloon and sat down to the table; as he felt considerably nauseated his order for the meal was very small. By bracing himself and holding on with one hand he managed to eat a few crackers and take a plate of soup, which he hoped would stay down long enough to give him a little nourishment, as he was badly in need of it. After this was over he made his way out on deck where he was almost appalled by the enormous size of the waves which beset the ship. It looked to him as if each one in succession would surely engulf the vessel. Finding that such occupation only added to his fears, he concluded to again go into the engine room. As he entered, the hot air and smell of burn-

ing oil nearly drove him back, and he was for a few moments in a quandary as to whether he would retain his light luncheon or not. Finally, by vigorous use of a lemon which one of the waiters had given him, he managed to dispel his approaching nausea, and by considerable mental and physical effort made his way to the lower engine room. Here he found the assistant engineer standing at the throttle with the same rank smelling old pipe in his mouth, but he was too busy even to look around, as the diving of the ship into the head sea caused the engine to race violently at frequent intervals. As she would run up on an approaching sea, the engine would almost come to a standstill, to be followed almost instantly by a tremendous spurt, wherein it seemed to the startled college man that it was making about five hundred revolutions a minute. By the prompt shutting down of the throttle this running away tendency would be checked before any damage could be done. This brought the subject of marine governors vividly to his mind, and although he racked his memory he could not think of ever having heard or even read of a governor that worked successfully on a marine engine. Here, thought he, is a fine field for inventive genius, although he could now readily understand that the problem was not an easy one. Any mechanical device, he reasoned, would fail on account of acting too slowly, so he mentally concluded that the best field of experiment would be with electrical devices, wherein an electro-magnet could be arranged to act on the throttle lever. He further determined that at the first opportunity, he would try to get up some scheme to accomplish this purpose, and thus save marine engineers from one of their most disagreeable duties when a vessel is pitching into a head sea. Although the Professor did not realize it, he was arranging a job for

himself that countless bright men have been unable to solve.

As the Professor intended to devote his attention from this time on, principally to the engine room, he at once proceeded to make the acquaintance of the oiler on watch, whom he readily understood was a very important man to know. The oiler on this watch was a large, good natured Irishman by the name of Bernard O'Connor, known to his associates as plain "Barney."

In the intervals between Barney's regular rounds of oiling, for he had his work very well systematized, he would come up to the place where the Professor was sitting, and in a short time had grown very confidential with him, telling him as the popular expression goes "the story of his life." The college man was a good listener, and knew from experience that this was the best way to get at the oiler's views on different subjects. In the course of the snatches of conversation during the early part of the watch, he learned that Barney was one of that old school of engine drivers now unfortunately dying out, or at least not being replaced by men of similar ability. He had begun life on a large transatlantic steamer as a coal passer, where, after securing many hard knocks, he had worked up to be one of the best firemen on the line. Indeed, stories are told to this day of Barney's wonderful prowess with shovel and slice bar. "Ah!" said Barney, "I can knock the stuffing out of this whole gang in the fireroom now, even though I am on the shady side of forty." After firing for a number of years, he was put into the engine room as an oiler. He had knocked around from vessel to vessel, until there were but few ports in the civilized world that he had not visited. Having the natural wit of his race, he regaled the Professor with numerous amusing incidents of his experience. So pleasantly had the

time passed that the Professor had almost forgotten the discomforts of holding on and keeping from sea sickness. Now, having installed himself in Barney's good graces, he suggested that he be allowed to accompany him on his rounds.

"To be sure you can, Professor," said Barney. "Come on with me!" Being in the lower engine room, they first went to the H. P. excentrics, which Barney slapped with the flat of his hand on each side, and remarked: "Cool as a cucumber, Sor;" he then squirted some oil in the oil cups, more of course in the go-ahead excentric than in the other one. The Professor reached out his hand in imitation of the oiler, and made an attempt to feel of the side of the go-ahead excentric strap; as he did this very slowly, his hand missed the H. P. strap, and he felt of the backing strap instead, at the same time narrowly escaping having his hand caught between the two straps. This caused Barney to ejaculate, "Niver touched it, Professor!" He then explained to the book man that he must give his right hand almost the same motion as the excentric, but to always keep just a little behind it. After several attempts, the Professor caught the motion and succeeded in feeling both straps. He said, "So you call those straps cool, do you? Why, I think they are quite warm." "Ah, Sor!" rejoined Barney, "that's where you're mistaken; they are plenty cool enough." The Professor concluded that feeling bearings, etc., must be largely a matter of judgment, based on comparisons. Barney next lifted out a tallow box, put his hand in and felt of one of the main bearings, nodding his head to indicate that that was in a satisfactory condition.

The Professor followed his example and found that feeling main bearings was a comparatively easy matter, but he wondered what purpose the cup full of tallow

served. Asking his companion, he was told that it was supposed that the tallow would melt and lubricate the bearing in the event of its becoming overheated. Barney said, "That's what it is supposed to do, but the box don't go within a half an inch of the journal, and by the time the journal gets hot enough to melt that grease, it's a hose you'd be needing instead of ile." This struck the Professor as being rather logical, and he made a mental note of that matter. Barney then proceeded in a very easy manner to feel of the crank pin brasses on each side, at the top and at the bottom. This also seemed to please him, for he proceeded to squirt some oil in the cup on the side of the rod. The Professor made a motion as if to feel the crank pin, but was interrupted by Barney, who said, "Hold on there, Professor, this ain't no cinch; wait until I show you how it is done." He then carefully instructed his newly found friend to move his hand in a motion so that it would follow just under the crank pin, and to be sure that the movements of his hand kept exact time with the revolutions. The Professor made motions outside until he thought he had them down fine, when he quite confidentially stuck his hand near the crank pin and gradually worked it in towards the brasses, keeping time with the revolutions. At first the tips of his fingers just touched the projections on the brasses, and he grew a little bolder. The first thing he knew he had lost the motion, and with an expression of pain he withdrew his hand, but not until the thumb nail had come into violent contact with the top edge of the brass. That the nail had not been torn off was very fortunate, but the end of his thumb was sufficiently bruised to keep the Professor from feeling any more crank pins, unless the engine was stopped. Thus they went along the engine, and Barney felt of each excentric, crank pin and main journal

in turn, finding them cool and administering more or less oil to each as they required. They then went to the thrust bearings, and at Barney's invitation the Professor stuck his hand in to feel of one of the rings, only to draw it out much more quickly, as he thought his finger was burned. "Surely you call that hot, don't you, Barney?" "Oh, no, Sor!" said he, "wait until she smokes, and then its time to get worried over thrust bearings." The Professor noticed, however, that there were several small streams of water running on the outside of the bearing, and that the tallow which the oiler put in between each ring melted almost as quickly as it was put in. They then walked down the shaft alley, where the three spring bearings were found to be running cool. The stern tube gland having a small stream of water playing on it was also found to be cool, so they retraced their steps and went up on the platform. Here Barney began by squirting a little oil on the H. P. valve stem guide, then in turn gave all the little journals about the links a squirt or two, felt of the crosshead brasses, and gave them a little oil; then felt of the guides and oiled them. In this way he attended to the intermediate connections, and finally the low pressure connections, the Professor following along and watched him closely. He next drew a quart of cylinder oil and filled up the sight feed lubricator on the high pressure steam connection. Then he got up on top of the cylinder heads and put some cylinder oil in each cylinder and valve chest. Going down on the grating again, he got an old tin bucket which was half filled with cylinder oil, and with an improvised swab began daubing cylinder oil on each of the valve stems and piston rods. "Now, Sir!" said he, "I am through for a few minutes, until the old ticker over there points to another half hour. The Professor now had a fair idea of the system of lubrica-

tion in vogue, and as he had made a study of several different systems, he decided to make some suggestions with a view to ascertaining Barney's practical ideas on the subject. He was becoming convinced by this time that he had much to learn from such men as this oiler, who had spent his life at the business, and he also felt satisfied that he might, from his wider range of vision, give them a great many ideas which would be to their advantage. Accordingly he opened up by saying, "Barney, is it necessary for you to use so much oil in the cylinders?" To this the oiler answered, "Well, I don't exactly know that it is, Sor, but I always have used considerable of it, and I suppose everybody else does." The Professor then told him that there were a number of torpedo boat engines in the navy, the cylinders of which had never had a drop of oil put in them, and that they ran along without any difficulty. The whole fact of it is, he continued, entirely too much cylinder oil is used in marine engines. The result is that it, of course, passes out with the steam, gets into the condenser, where it reduces its efficiency by becoming smeared over the surface of the tubes. In spite of the fact that effort is made to filter it out in the feed tank, more or less of it is bound to remain mixed in with the feed water, with which it finally enters the boiler. The result is that it practically ruins tubulous boilers; in Scotch boilers, if they are not given frequent cleanings, the furnaces are liable to drop. It coats the tubes of Scotch boilers, and as it is absolutely impossible to clean these, except the outside rows, the efficiency of the boiler is greatly decreased. The consumption of fuel may be practically the same, but the steam generated will never be so great as when the boilers are brand new, all due to the use of large quantities of this cylinder oil. "Phew!" said Barney. "Shure I had no idea that cylinder oil

would raise such a divil of a fuss as all that." "Indeed it does, my man, and even worse than I have told you. Now, Barney, I want you to try and see if you can't use just half the quantity of cylinder oil during your next watch. I will come down here with you, and we will observe things together, and talk over lubrication matters still further." He handed Barney a few cigars, which he had laid in for such occasions, and went out on deck, where he found that the gale had subsided considerably, but that the sea was still running pretty high.

CHAPTER V.

SOME POINTS ON LUBRICATION.

The following morning the Professor went on deck early and found that the storm had entirely subsided, although there was still a considerable roll on. The sky was clear, without a sign of a cloud in sight, and there was every indication that the day would be very hot. The sailors were busy about the decks, sweeping and setting the awnings. He first went in to breakfast, and after eating heartily, felt so much refreshed that he decided to devote nearly all day to the engine room.

After a few moments' pleasant conversation with his brother, the Chief Engineer, he put on his overalls and went below. After greeting the engineer on watch, he went down to the lower engine room and met his new-found friend, Barney, the oiler, who was hustling around at his work, humming an old Irish ballad and vigorously smoking his pipe. "Good morning, Professor," said he as he caught sight of the visitor. "I'm going to see what I can do towards using less cylinder ile this morning." "That's right, Barney," replied the Professor. He then went up and spoke to the engineer of the watch and got his permission to reduce the supply of oil in the cylinders. The automatic lubricator on the main steam pipe was then slowed down so that only about two drops a minute passed through. The oiler going off watch at 8 o'clock, had put some oil in the cylinders through the cups screwed into the cylinder covers, as the custom was to give a little oil to each cylinder every hour in this manner. When 9 o'clock came Barney appeared a little fidgety, and said that he was afraid if he did not put some oil in the cylinders she would "grunt," as he expressed it. "We will try it, anyhow," said the Professor.

Noticing the oiler come up on the grating with a two-gallon feeder in his hand, and commence filling up the reservoirs for the automatic lubricating systems, he turned to the engineer and said that nowadays the best practice was to have a 25 or 30 gallon reservoir fitted as high up in the engine room as possible. By means of a pump in the lower engine room connected to the main oil tanks, this overhead tank could be filled without carrying oil around the engine room. To fill the reservoirs on the sides of the cylinders, all that was necessary was to open a cock or small valve and let it run in by gravity. Noticing that these small reservoirs were of the old-fashioned cast brass kind, he stated that the best type he had seen were cylindrical in shape, and that the ends were of glass, so that the height of the oil in them could be seen at a glance. This brought up the subject of automatic lubrication, and the Professor informed the engineer that he believed a great deal of oil was wasted by such methods as those in general use. The regulation of the feeds, he said, appeared to him to be of great importance. If left entirely to the oiler, he would be liable to give the various pins and bearings too much oil in order to be on the safe side, and also to save himself the trouble of getting around and feeling the bearings too often. He said that he was of the opinion that for ordinary running the best plan would be to give only the crossheads and crank pin brasses steady lubrication, and let all other journals be oiled by hand at regular intervals. The assistant engineer said that he was not very much in favor of automatic oiling either, as he had on several occasions experienced difficulty in having the oil pipes plug up or in having the feed valves clog.

The Professor suggested that these difficulties would probably be overcome if the inside surfaces of the pipes

were tinned, in order to prevent the formation of verdigris, caused by the acids in the oil, making a chemical combination with the bare brass of the pipes; and also stated that the oil should be properly strained before it was put in the reservoirs to avoid the "clogging up" of the feed valves. Noticing that they were using lard oil, he asked why they did not use a mineral oil. To this query, the assistant replied that he did not know any good reason for not using it, only that they always had used lard oil since he had been on the ship. The Professor then stated that he had made laboratory experiments with certain grades of mineral oils and found that their lubricating qualities were better than lard oil. In addition to that he said that mineral oils would not smell so badly in the bilges as lard oil, and that he understood that the mineral oil was cheaper. From conversation with many sea-going engineers he said that he had formed the impression that it was only prejudice which prevented them from using mineral oils, instead of the old-fashioned practice of using lard oil for everything. Barney, who had been listening to this discourse, chimed in just then by saying, "Yes; and that hog grease is moighty bad stuff when it gets thrown in your eyes or gets into a cut on your hand."

It now lacked only a few minutes of 10 o'clock, and as yet no "grunts" had been heard from the cylinders or valve chests. However, the Professor suggested that a little cylinder oil be put in the three cylinders. "That's right," said Barney; "she's loike an old toper, it won't do to shut off her allowance too short."

The Professor continued his discourse on lubrication, and said that he had been informed that many engineers used grease compounds wherever possible, some even using it on the main bearings. He said that he considered this as rather bad practice, and that on

bearings or journals having comparatively little motion grease could be used with advantage. For instance, he said, grease cups on those journals on the drag links would be all right, and more economical than using oil. He also said that grease cups would be all right on reverse shaft bearings. Coming to the subject of oiling main bearings, he said that he considered it a mistake made by many to put oil in the middle of the bearing only, contending that as the ship always had more or less drag, the tendency of the oil was to run aft and thus leave the forward parts of the bearings unlubricated. Oil boxes on main bearings, he contended, should always be fitted with two wick feeds, one on the forward end of the cap or binder, and the other on the after part.

On the subject of eccentric straps, he said his idea would be to oil them by hand, through a small cup secured to the side of the eccentric rod, and having a pipe leading to the center of the bearing surface on top of the strap. With slide valves the eccentrics had to do considerable work, and unless they are designed with large bearing surfaces they are very liable to warm up. He suggested that to save using such a large amount of oil on eccentrics, as is customarily used to keep them cool, they could be arranged to dip into fresh water held in galvanized iron or sheet brass drip pans secured beneath each pair of eccentrics. Barney said, "Yes, and it's a foine lot of lather you would have by churning up that mineral oil and fresh water in an ould drip pan." "There's where you are mistaken, my man," replied the Professor. "While it is true that the ordinary mineral engine oil will make a lather when mixed with fresh water, there is a non-saponifying grade of oil that will not produce that trouble. Before Barney had a chance to ask questions, the Professor explained that "non-saponifying"

meant literally that it would not make soap. "Shure," said Barney, "I wish it would make some soap, as it's little enough we get aboard here to wash our clothes in."

As it was time to oil the piston rods and valve stems, the old oiler got out a tin can, which he had half filled with cylinder oil, and proceeded in a dextrous manner to coat the surfaces of the rods with oil by using a swab improvised from a stick and a bunch of waste. While he succeeded in getting the most of the oil on the rods, there was a considerable portion of it that dripped down on the connecting rods and valve gear. This, the college man thought, was a rather bad practice, so he explained to the oiler that on many modern ships he understood that each valve stem and rod had a separate oil pump secured to the cylinder casing in a convenient position, with a small pipe connecting directly to an oil space just inside of the supplementary gland, in the stuffing-box. By a few strokes of the pump sufficient oil would be forced in to thoroughly lubricate the rod. He went on to explain that for the high pressure valve stem and piston rod there was sometimes a pressure of steam in the oil groove in the stuffing-boxes, and that it was usually the practice to fit a small check valve in each of the pipes connecting the pumps to the stuffing-boxes. "That ought to be a fine scheme," said Barney, "as it won't dhribble any ile over the engine."

"Barney, what becomes of all the oil that drips off the engines?" asked the Professor. "Well," said the oiler, "I suppose the poor fish must get it, as it all goes in the bilges and is pumped overboard." "There, again, the ship is behind the times," said the Professor. "The modern practice is to have the crank pits made water tight, and each fitted with a strainer and drain pipe. All these drain pipes lead into a large pipe,

and that empties into a galvanized iron tank fitted in between the frames aft of the bed-plate, and lower down than the bottom of the crank pits. The waste oil is then drained into the tank, from which it can be baled or pumped out about once a watch. This waste oil on some ships is put through a filter and can be used again. That is another contrivance that is coming into use; in fact, every large ship should be furnished with a good oil filter, as it will soon pay for itself in the amount of oil saved by it, which would otherwise be pumped overboard and wasted." Barney replied that the oil tank scheme wouldn't work, as the discharges from the water service would fill the tank up in very short order. "That is no drawback," said the Professor, "as the water service discharges should lead directly into the bilges and not go into the crank pits at all."

The Professor's attention was next attracted, as it had been on the previous day, to the fact that ordinary tallow was being used in the thrust bearing. Barney was stuffing some rancid tallow in between the rings, and at the same time elevating the end of his nose. "Professor," said he, "can't you get up some way of iling this thrust instead of this stinking tallow?" "Why, yes, Barney; there is a much better method in use on new vessels. Nowadays thrust bearings are so designed that the lower part forms a water-tight box. This is filled with oil, and the collars are about half submerged in it. As they revolve sufficient oil is carried up to thoroughly lubricate the horseshoe bearings. Of course the oil gets warm from the great amount of friction, but it is quite easily kept cool by circulating sea water through a pipe coil in the bottom of the oil chamber. It is the custom with this style of thrust to fit an oil-tight cover, made of sheet iron or brass, over the top of the bearing to keep the oil from being

thrown out in the shaft alley." This idea seemed to meet with Barney's approval, and he remarked that he would like to get on a ship with some of the labor-saving devices which the Professor had described to him.

The college man was by this time pretty nearly worn out by the intense heat, and as it was near the noon hour he went to his room, washed up, and ate his dinner. He lingered around on deck for a time, enjoying the welcome shade of the awnings. The ship was now in the tropics, the heat was becoming very oppressive, and the Professor shuddered when he thought of again going into the engine room. However, as he had made up his mind to spend all day there, he reluctantly put on his perspiration-soaked overalls and again went below. The heat was even greater than it had been in the morning watch, so he walked over until he got under one of the ventilators. There he was joined by the first assistant, who had the watch. The Professor told him what success he had met in regard to using less cylinder oil, so the engineer called up his oiler and told him to put oil in the cylinders only twice during the watch.

Looking over at the engine room thermometer, the Professor saw that it registered 128 degrees. The officer on watch assured him that that was nothing unusual, and that he expected it would get even higher than that. This somewhat startled the book man, and he wondered if he could stand it any hotter than it was. The hot air made the membrane in his nostrils smart, and he concluded that, although there were some pleasant experiences in a marine engineer's life, this standing a four hours' watch in the tropics was not to be numbered in that category.

Going down below he found the atmosphere in the lower engine room somewhat cooler, but hot enough at

the best. "Why don't you take off your jumper?" said the oiler. This the Professor proceeded to do, and as he stood there, arrayed in undershirt and overalls, he did not present a very dignified appearance, but he found it much more comfortable.

After making a thorough examination of the water service, as that seemed to be the only cool apparatus in the engine room, he rejoined the first assistant under the ventilator. He asked him if they had much occasion to resort to the use of water on the journals, and was told that it was very rarely used, except the regular circulation through the guides and main bearings. The Professor said that he noticed that the pipes over the crank pins were bent in many places. This, the first assistant replied, was caused by the men standing on the pipes when overhauling the engine. The Professor suggested that it would be a good idea to make them of extra heavy pipe and secure them firmly to the main pipe at the back and to the columns in front. "I notice," he continued, "that the main supply pipe running along the side of the condenser is of ordinary brass pipe. In my opinion, it should be of cast brass, eccentric in section and not less than ½ inch thick at the heaviest part. This would give a firm support to the branch pipes, without brazing or bosses, as you have them here." He went on to tell the assistant of a scheme which an ingenious friend of his had arranged on a Government vessel whereby all the discharge pipes from the main bearings were led to one central location and secured to a bracket, the ends of the pipes being spaced about an inch apart. The engineer or oiler could then tell by running his hand through the several streams if any of them appeared to be warmer than the others. In this way his friend claimed that he could at once ascertain whether any of the bearings were becoming the least bit heated, and

just which they were. The same arrangement could be applied to the discharge pipes from the guides.

In order to observe the working of the air pump, the Professor walked around back of the engine and stood there in meditation for awhile. He suddenly felt rather faint and everything began to look black before his eyes. He made a rush to get out of the engine room, and as he half stumbled out of the door the ship's doctor happened to see him in time to prevent him from falling on the deck. Summoning one of the waiters, he shouted: "Run quickly and get me some ice; the Professor has been overcome by the heat."

CHAPTER VI.

WHY ENGINES ARE INEFFICIENT.

When the Professor regained consciousness he found himself lying in his berth, with the doctor standing over him. A dim recollection of what had happened gradually dawned on his mind, and in a feeble voice he inquired of the medical officer his opinion as to whether he was going to die or not. To this the physician replied in a very cheerful manner that there was nothing serious the matter with him, and that such accidents were of somewhat frequent occurrence to the men in the engineer's force. Feeling somewhat encouraged, the Professor lapsed into a meditative mood and tried to recollect the circumstances attending his attack. He could remember distinctly that he was standing near the air pump when the thing happened; he had an indistinct memory that the air pump began to roam around the engine room and that the grating flew up and struck him. Beyond that all was a blank, and he shuddered to think of what he had been through. The doctor gave him a little stimulant and he gradually began to take interest in his surroundings. In the afternoon his brother, who had been greatly worried over his brother's prostration, came into the stateroom and spent several hours with him. The chief succeeded in cheering him up considerably, but could not resist the temptation to joke with him good naturedly about his present idea of the theory of heat and thermodynamics.

Under the cooling influence of an electric fan and the gradual administration of nourishment the Professor's condition was so much improved the next day that the doctor allowed him to sit out on deck in a

comfortable steamer chair. On the afternoon of the same day Barney, the oiler, who was "off watch" at the time, came up to the convalescent, and, making a bow, said: "Professor, I'm glad that you are able to be around. Shure I thought you was a goner this time." The Professor thanked him very kindly for his friendly expression, and told him to draw up a chair and sit down alongside him. Barney said that he would like to, but he was afraid that some of the deck officers "would chase him off," as he expressed it. The Professor assured him that he would make that matter all right if anybody questioned the propriety of the oiler sitting on deck among the passengers, so Barney got a camp chair and sat down. As the Professor did not feel much like talking, Barney took advantage of the opportunity and spun a number of yarns in regard to the many funny experiences he had encountered in his travels. These put the college man in a good humor as he laughed heartily at a number of the Irishman's witty tales. Finally the conversation turned to the subject of engine room heat and the discomforts encountered in the engine and fire rooms of steamships. Barney assured the Professor that it "was all in getting used to it." To this remark the Professor shook his head and said that he was afraid he would die in the attempt. Barney said: "Oh, never mind, it won't be long before they'll be running all steamships by electricity, and all the engineer will have to do will be to sit down in an arm chair and open a switch." The Professor replied that he was afraid that that happy state of affairs would not be brought about in their lifetime.

"You see, Barney," he continued, "that the only method by which electricity can be developed on board ship at the present time is by the steam engine. Storage batteries are used to some extent on launches and

small yachts, but they can only travel short distances, and must never get a great distance from the power station. So long as electricity has to be generated by a steam engine it will be of no practical utility for ship propulsion. The marine engine of today is, at the best, very inefficient, and it would be still more so if an attempt was made to apply the power to the propellers through the medium of electricity."

The first assistant engineer, who was also off watch, happened along in time to hear this last remark, and as he looked upon Barney as a sort of privileged character, he also drew up a chair and sat down."

"Professor," he said, "what do you mean by saying that the marine engine is very inefficient? From what I have read on the subject I have always understood that a marine engine was about the most efficient type of engine made, and especially when compared with the ordinary type of stationary engine."

The Professor replied: "Yes, that is true, Mr. B——, and perhaps it would have been well for me to have said that any steam engine is very inefficient from a theoretical standpoint. You can readily see that the only way that the efficiency of a steam engine, or in fact any other kind of an engine, can be determined is to compare the actual power developed by the engine and applied to the propulsion of the ship, with the power that should be developed by the consumption of the fuel if none were lost in the process of conversion. It will no doubt surprise you when I state that with the very best types of marine boilers and engines not over 15 or 20 per cent of the power supposed to be developed from the amount of coal used is usefully applied in driving the ship."

To this his listeners both expressed surprise, and Barney remarked that he "knew mighty well that thim firemen didn't half burn the coal in the furnaces."

"Oh! it is not careless firing that accounts for this waste," replied the Professor, "although of course that accounts for a small part of it." The first assistant evidenced a great deal of interest in the Professor's remarks, and asked him if he would not explain wherein there was such a great lack of efficiency. To this the college man readily assented, and after drinking a glass of lemonade which one of the waiters had brought him, he proceeded thus: "You see, scientific men, by a series of experiments in laboratories, have determined that the perfect combustion of one pound of coal would produce on an average about 14,000 British thermal units."

Barney said: "I don't know phwat that is, but why don't they use Irish units?"

This caused the Professor to smile, and he replied that they probably would have called them Irish thermal units if an Irish scientist had determined their value. "However," he said, "a B. T. U. is the amount of heat that is necessary to raise the temperature of one pound of absolutely pure water one degree on the ordinary Fahrenheit thermometer. On board ship it is not possible to burn coal and obtain a perfect combustion such as was done in the laboratories. This is accounted for owing to the impossibility of having furnaces designed to suit the various kinds of coal met with at different ports, and to regulate the admission of a proper amount of air. This imperfect combustion results in the escape of unconsumed hydrocarbon gases, and in the formation of what is known as carbon monoxide, evidenced by a blue flame, which passes off through the stack. Ordinary coal consists of from 75 to 80 per cent of carbon, 2 to 5 per cent of hydrogen, 10 to 15 per cent of oxygen and small percentages of nitrogen, sulphur and ash. The constituent which produces the heat is principally carbon, although hydrogen

and sulphur aid a little. This carbonic oxide takes a portion of the carbon away without producing any heat."

"It must be a regular robber," said Barney.

"Yes, you can call it that," said the Professor, and continuing, said: "another great source of waste is that considerable of the heat applied to the water is lost on account of the radiation. Dirty tubes, or tubes partially stopped up by soot are also accountable for more waste of the heat of combustion. The chief loss of the heat is, however, that which goes up the funnel with the waste products of combustion. A certain temperature of these waste gases is, however, necessary for the maintenance of a suitable draft, so that this loss exists of necessity and cannot be reduced below certain limits. As a fair average it can be said that with the ordinary coal used on shipboard, and with a well designed boiler, it is only possible to transmit to the water and steam, under favorable conditions, about 65 to 70 per cent of the heat which would be produced by a perfect combustion of the coal used in the furnaces. The remainder of the heat is absolutely wasted, so that out of every 100 tons of coal bought by the steamship owners at least 30 tons might as well be thrown overboard, so far as any useful work is concerned. Now as to what happens in the boiler. In the first place if you should boil water in an open pot or kettle, that is as we term it, at the pressure of the atmosphere and place a thermometer in it, you would find that the temperature would gradually rise until it reached 212 degrees on the Fahrenheit scale. The mercury would then stop rising for some time, no matter how much fuel you would add or how much you forced the fire. After a while steam would form and escape from the surface of the water. During this time and while the thermometer was con-

stantly showing 212 degrees, heat was constantly being added to the water, and eventually caused it to change from its liquid state into the form of vapor or steam. The heat absorbed by the water during this period is known as the heat of vaporization or latent heat. Although it only takes 180 thermal units to raise the temperature of a pound of water from freezing or 32 degrees to the boiling point or 212 degrees, it has been found that it takes 966 thermal units to transform the water into steam at the latter temperature. The heat absorbed in bringing the water up to the boiling point is known as 'sensible heat,' because it is indicated on the thermometer.

"Will that 'later heat' raise a blister on your skin as quick as the sinsible heat?" inquired Barney. The Professor was too much absorbed in his discourse to notice this interruption on the part of the oiler. Continuing, he explained that although water boiled at 212 degrees under atmospheric pressure, if confined in a closed vessel, the boiling point gradually rose with the pressure. At a pressure of 180 pounds in a boiler, the water would not begin to be transformed into steam until the thermometer registered 380 degrees.

When the steam leaves the boilers it, of course, passes to the main engines through the main steam pipe, and even in passing this short distance you may have noticed the pressure is somewhat reduced, owing to the friction in the pipes around the bends and through the stop and throttle valves. This drop in pressure indicates still further loss. When it enters the cylinders there is a certain quantity of it condensed into water, owing to the surfaces of the valve chest, cylinder passages, piston and cylinder heads being at a lower temperature than the steam itself. This loss of heat is attributed to 'cylinder condensation,' and amounts to considerable. Then there are

losses of steam through leaky stuffing boxes. The very heat in the engine room which overcame me the other day is a great loss to the efficiency of the engine (not to mention the effect on the men in the engine room), as it is all radiated from the pipes or cylinders. The greatest engine room loss, however, is in the condenser. When the steam leaves the low pressure cylinder its sensible heat has been greatly reduced, so that it is now almost down to the original boiling point. Here, again, we have to contend with the latent heat. In order to transform the exhaust into water again the vapor has to pass through a molecular change. The heat thrown out in this change is transferred to the circulating water, and is passed out into the sea without having done any work."

Barney said: "We ought to set a trap in the outboard delivery valve and catch some of it."

"Well, my man, if you can devise any scheme to utilize a good proportion of this heat, your fortune is made."

"Shure that's aisy," said Barney. "Whin I was on one of the American liners they use to pump up the discharge water for the passengers to bathe in."

"Well," said the Professor, "that no doubt added to the comfort of the passengers, but I don't think it reduced the coal bills to any great extent."

"After all you have said," remarked Mr. B., "it does look as if a steam engine was not very efficient." The Professor then said, "I have only pointed out some of the losses due to the use of the steam. In addition to those we must also take into consideration that there is a considerable loss of power on account of the friction of the working parts of the engine, and in the thrust and stern bearings as well. Then, too, the loss due to the action of the propeller in the water must not be lost sight of."

"Can't some of these losses be reduced?" inquired Mr. B.

"Oh, yes," was the reply; "the estimates I have given you are such that are met with on an average ship, but on very carefully designed and ably managed vessels the efficiency I have named is considerably increased. For instance, in the consumption of fuel, the average ship fitted with a triple-expansion engine uses from 1.8 to 2.0 pounds of coal per indicated horse power per hour, but there are triple expansion engines in use where the consumption of fuel is reduced to as low as 1.5 pound per horse power per hour, and even to about 1 pound in rare cases. This gain in efficiency is accomplished by having well designed engines and boilers, the use of feed water heaters, the heating of the air furnished to the furnaces for combustion, the stoppage of all steam leaks in boilers, pipes, engines and stuffing boxes, etc. Careful firing also adds greatly to the efficiency of a steam plant. Perhaps the most important of these items is the heating of the feed water. It has been estimated, for instance, that on a ship where the feed water is pumped into the boilers at a temperature of, say, 100 degrees, if a heater is fitted which, without entailing any use of heat otherwise useful, raises the temperature of the feed water to 212 degrees, a net saving of nearly 10 per cent in the fuel will be accomplished."

"If that is so, why are not more feed water heaters used?" inquired Mr. B.

"I can only attribute it," was the reply, "to what may be termed 'old fogyism' on the part of old engineers. They go on the principle that feed water heaters were not used on ships when they first went to sea, and they can see no reason why they should use them at the present day."

It was now nearing eight bells, and the first assistant

and Barney, who had to go on watch, took leave of the Professor, after thanking him for what he had told them. The Professor spent an hour or so looking out over the blue water and watching the flying fish arising in flocks when chased by some hungry dolphin. Being still somewhat weak and tired, he gradually fell into a doze, to dream of distant places where there are no broken gauge glasses nor hot engine rooms.

CHAPTER VII.

SALT WATER AND BOILER SCALE.

When the Professor awoke from his refreshing slumber he found that the afternoon had nearly gone. The Captain announced to the passengers that they would, in all probability, sight land early the next morning, and that they would anchor in the harbor of St. Thomas, Danish West Indies, by eight o'clock. This was very cheering news to the Professor, and the prospects of lying in a smooth harbor where the ship would cease to roll for a time, not to mention the chance of stretching his legs on shore, proved very exhilarating. For the first time since he was overcome by the heat he sat down to the table, where he was congratulated upon his rapid recovery by a number of the passengers. Indeed, from the vivacity of his conversation, one could have well imagined that he had partaken of some very potent tonic to bring about such a change in his demeanor. With considerable glee he discussed the probability of the news that they would hear of the busy world since their departure from New York. He also made arrangements with several congenial persons to make a short sight-seeing trip on shore the next day. After dinner he resumed his seat on deck. He was soon joined by the Chief Engineer, who, after congratulating him on his improved appearance, told him that a number of the tubes had been found to be leaking so badly in the port forward boiler that he had been compelled to cut it out, and let the fires die down. He announced his intention of having the leaky tubes removed and new ones put in, after they got in port.

"As this will take us at least 48 hours, I will improve the opportunity and have the boiler given a thorough cleaning."

This statement led the Professor to inquire as to when the boiler was last cleaned. To this the Chief replied that the boiler in question had not been given a thorough cleaning in over a month. The visitor expressed considerable surprise at this remark, and said that he thought a boiler constantly under steam should be cleaned at least once in two weeks.

"That's all very well in theory," responded the Chief, "but you would find out, if you were running the steam machinery on a passenger ship, that you would not have the time to clean boilers so often. The owners want to keep the ship moving as rapidly as possible, and with the short crews they allow us in the engine department, we have to hustle to keep up even ordinary repairs and adjustments. If it were not for the fact that I have got to put in a lot of new tubes I wouldn't attempt to take the time for cleaning while we stop at St. Thomas."

The Professor argued that it would pay the vessel owners to take the time to have the boilers cleaned, claiming that the delay would be more than compensated for by the additional speed the vessel could make with clean boilers. He further added that if more care was exercised in the use of cylinder oil there would not be so much necessity for cleaning the interior of the boilers.

"It is not alone the cylinder oil that gives us trouble with the interior of our boilers," said the Chief; "we also have to contend with scale."

"I shouldn't think there would be much scale in your boilers, as you use an evaporator for the make-up feed supply." "Of course we do," said the Chief, "but you evidently forget that it is almost impossible to

get a surface condenser perfectly tight, and as a result there is bound to be more or less leakage from the salt water ends to the steam side. In this way the salt water gets into the feed system and the result is that, in spite of the greatest care, a mixture of oil and scale is formed on the heating surfaces. You theoretical people imagine that because a condenser may be tight when it is first built, it will remain so for the rest of its existence."

"Oh, no, we don't," replied his brother, "but I did not imagine that the leakage in the condenser would have any appreciable effect on the formation of scale in the boilers." "Why," continued the Chief, "you have no idea of the different ways salt water does get into boilers sometimes. I have known cases where a vessel has been lying alongside of the wharf for a week or so, and the main condenser not being in use; yet in a few days I have discovered that the water in the boilers had become salted. This condition was no doubt largely due to carelessness on the part of the water tenders. For instance, when they use the auxiliary feed pump for pumping up the boilers they never took time to pump a few strokes overboard to get rid of any salt water that may have been in the pump cylinders and pipe connections. Another cause is that they neglect to close the sea suction valve tight on the manifold, and the result is that a small amount of salt water will be drawn in from that source; then, too, the sea suction valve may leak, in which case salt water will leak in, even if the valve is closed tightly. Why, I even caught one greenhorn who had been told to pump up the boiler from the fresh water tanks, with the bilge suction valve open, and there he was pumping bilge water in as feed water. You can bet that I put him on the dock in short order. It is all very well to wonder how

salt water gets into boilers, but when you have had some of the experiences I have met with, your only surprise will be that more of it does not get in. If every man in the force worked like a machine, it would be all right, but on board ship you must watch everything closely or else you will get into all kinds of difficulties."

The Professor saw the force of his brother's arguments and had no more to say on that subject.

"I suppose you will renew the zincs in the boiler when you clean it out," remarked the Professor after a pause.

"Oh, yes," said the Chief, "we will put some new blocks in if they are necessary; but I don't take much stock in the use of zincs anyhow; they are said to be of great benefit, but I don't see that it makes much difference whether they are in there or not." "That is probably due to the fact that your zincs are not properly fitted," retorted the brother. "I am surprised to find how few people really understand the object of fitting zincs in a boiler, and the proper method of fitting them."

"Well, I must admit that I don't understand the exact theory of it myself," replied the Chief, "but perhaps you can enlighten me."

This gave the Professor an opportunity to expatiate on his ideas of the question, so he commenced thus:—

"The principal difficulty encountered in the care and preservation of the interior of marine boilers is to guard against corrosion and pitting. General corrosion uniformly distributed over the inner surfaces is not so bad, as with ordinary care, its effect, even after the boiler has been in use for several years, is hardly noticeable. 'Pitting' is quite a different problem to contend with, as it is generally manifested locally and at times its action is very quick. There

are instances on record where new boilers have had to be re-tubed after being in service for only six months. Various theories have been advanced as to its cause, but it is now generally conceded that it is principally due to electro-chemical action. This action is on the same principle that electricity is generated in an ordinary electric battery, such as is used for ringing bells, etc. In such a battery, you know, a current is generated by the immersion of two metals or other substances of a different electrical potential, usually copper and zinc. The result of the continued submersion of these two metals in an acid liquid is the gradual disintegration of the zinc. A marine boiler containing water which has been allowed to become acid is in a manner an electric battery. With internal feed pipes, blow pipes, fittings, etc., of brass or copper, there is a tendency to start a flow of electricity between them and the steel of the boiler. The result is that certain portions of the steel or iron becomes disintegrated and leaves small depressions or pits in the surfaces under the water. The copper is not alone responsible for galvanic action, as a current may be generated between different grades of iron or steel and even between the metal itself and the scale formed on its surface. When lap welded steel tubes first came into use, it was found that they corroded and pitted much more readily than charcoal iron tubes. Many persons attributed this condition to the fact that steel was more readily attacked by this pitting action than iron tubes. The fact of the matter was that to get steel to weld properly the tube manufacturers were compelled to use material cut from the tops of the ingots as they were cast; this, as you know, is very spongy metal, and the result was that the tubes proved very unreliable and eventually went

out of use entirely. Since the advent of seamless drawn steel tubes it is found that they resist corrosion and pitting even better than charcoal iron tubes. Now to prevent this internal pitting the best plan is to keep the water from becoming acid. A galvanic battery will not work in absolutely pure water, and for that reason, as you may have noted, blue vitriol or sulphuric acid is put in the water of the cell. So it is with boilers, if the water is kept as nearly pure as possible, there is very little galvanic action. It is a very simple matter to test the water in a boiler; all you need to do is to draw out a glassful from one of the gauge cocks and drop in a small piece of litmus paper. If the water is acid the paper will turn red, but if it is alkaline the paper will retain its original color, blue. On naval vessels the engineers are required to make frequent tests of the water in the boilers for acidity. When it is ascertained that the water is in an acid condition steps should be taken to neutralize it by adding an alkaline solution, such as soda-ash. Zinc in the boilers also tends to neutralize the acidity, owing to the formation of zinc chloride during the decomposition of the metal. The principle use for the zinc is, however, to prevent the electro-chemical action, as it furnishes a material which is more electro positive to the copper, etc., than the iron or steel. Consequently the zinc is first attacked by the galvanic action.

"Now as to the method of putting the zinc in the boilers. From what I understand, the prevailing practice on board ship is to simply attach a clip to a slab of zinc and simply clamp it to the tubes or braces, without paying much attention to how it is secured. This is rather bad practice, for the zinc crumbles up and the detached particles get in the bottom of the boiler and are liable to stop up the blow valves. A

much better practice is to place several slabs in a basket made of wrought iron or steel plates. The sides and ends of these baskets should be perforated so as to allow a free circulation of the water through them. The bottoms of the baskets should be left solid so as to catch the small particles of zinc as they become detached by the galvanic action. The most important thing to be considered is to have metallic contact between the zinc blocks and some parts of the boilers. That portion of the brace or tube to which the clamp for supporting the basket is to be secured should be filed bright, and the clamp should then be secured tight. It is also a good idea to cover the joint between the clamp and brace with putty or cement to keep the water from rusting the joint. The handle to the basket should be riveted to the sides, and if possible there should be an iron bolt passing through the sides of the basket and through each block of the zinc. Just here it may be well to call your attention to the fact that the blocks should be separated from each other. If they are put in so that they touch each other, it will be found that the blocks will swell and naturally burst the basket.

"Rolled zinc is said to be better for this purpose than cast zinc. However they are placed, the greatest care must be exercised to secure and maintain the metallic connection, as otherwise the zinc will be of very little use. Care should also be taken to distribute the zincs in such a manner that all of the inner parts of the boiler are uniformly protected."

The Chief had been listening attentively to what his brother had to say in regard to zincs, and at the conclusion of his remarks said, "I had no idea that it was so important to fit these zinc blocks so care-

fully, and after this I will give that matter more attention."

The Professor looked at his watch, and finding that it was getting rather late in the evening, told his brother that as he still felt somewhat weak and fatigued, he would retire, so as to get up early in the morning and be ready to go ashore.

At six o'clock the following morning the Professor was called, and as he got up and looked out of his stateroom window he was much elated to see that land was plainly visible straight ahead. After dressing he went out on deck and found that most of the passengers had also risen early and were gathered in groups on the upper deck gazing wistfully at the green hills in the distance. Good humor prevailed and the Professor secretly wished that the land in sight was the coast of New Jersey and that they were about to enter New York harbor. All hands ate an early breakfast and began making preparations to go on shore. Shortly after eight o'clock the anchor was dropped and the ship was safely moored in the harbor.

The Professor looked into the engine room door, and stood there in meditation for a few moments. The men on watch had already begun to wipe down the engine and clean up around the engine room. The college man could not help but compare the engine with a thoroughbred horse which had just finished a hard run and was being groomed by the attendants. But how different the work performed by the animal and by this creation of man! Ever since the vessel had left New York over a week before, the faithful engine had kept steadily at work hour after hour, day after day, never tiring, but keeping up a continuous turning of the propeller. He also made mental comparisons between the performance of a

marine engine and that of locomotives and stationary engines. After a run of a few hours a locomotive is taken to the shelter of a round house and groomed for another run on the following day. Stationary engines run during working hours and are usually shut down half the time; but the sturdy marine engine must keep going day after day for periods often as long as fifteen or twenty days at a stretch, without ever stopping. The safety of the ship and the lives of the passengers and crew depend upon its faithful performance of duty. Surely, throught the Professor, man has created no more wonderful mechanism than the marine engine. Too much care and attention cannot be exercised in their construction, nor too much credit given to the men who successfully operate them at sea. While thus absorbed in thought, Barney approached him unobserved and somewhat startled the Professor by saying:—

"Well, sor, you look as plased as if you had just got a letter from home with money in it."

"I feel somewhat that way, Barney," replied the college man.

Just then one of the sailors came up and told him that the boat was ready to take the passengers ashore. The Professor got out his sun umbrella and climbed into the boat with a party of the passengers. Soon they were at the landing and as they stepped out, the usually sedate looking college man had the appearance of a colt let loose in a pasture. If he had known how, it is within the bounds of possibility that he might have attempted a cake walk.

The party of passengers wandered about the town, visited the fort, called on the American consul, purchased curios, took a drive out in the suburbs and in the evening took dinner at one of the leading hotels. After dinner they sat out in the park listening to the

music of a very good military band. The tropical air was scented by the numerous flowers in the park, and as the evening was cool, the party enjoyed their brief respite on shore to the utmost. When it came time to return on board ship, the Professor and one or two others made up their minds to stop at the hotel over night. The Professor had never before realized what a luxury it is to stretch out in a large roomy bed, and he concluded that a sailor's life is not a happy one, when compared with that of any ordinary citizen on shore.

CHAPTER VIII.

CLEANING BOILERS IN A TROPICAL PORT.

When the Professor awoke on the following morning he thought he must be in Fairyland. It was quite early, and the usual morning breeze of the tropics was blowing in through the open windows. Looking out he could see the tall palms and cocoanut trees in the hotel grounds nodding in the breezes, and the air seemed to be permeated with the fragrance of tropical flowers. The birds were singing merrily, and, in fact, all nature seemed to be in a laughing humor. With such pleasant surroundings the Professor was loath to arise, so he remained in bed until about 8 o'clock, when a knock came at his door and he was informed that breakfast would soon be over. After partaking of a light breakfast, consisting of fresh fruit and eggs, he walked towards the wharf, feeling like a different man entirely, and contrasting his present surroundings and feelings with those of a few days before, when the ship was rolling and pitching in a gale of wind. Being somewhat of a philosopher, he soliloquized that, after all, pleasures are only matters of contrast. Had he been sleeping in a wide bed in a cool room for the whole week before he would not have had the feeling of exhilaration which he was then enjoying. He also concluded that the ratio of such mornings to the mornings of discomfort on shipboard was entirely too small to cause him to spend the remainder of his life going to sea.

Arriving at the wharf, he found the usual motley crowd which is always in evidence along the water front of a tropical seaport. Scantily dressed negroes of

both sexes were lolling around; market men were vending their wares and a general air of confusion seemed to prevail. As soon as he stopped walking and looked out in the harbor he was surrounded by a dozen importuning boatmen, who all wanted to row him off to the ship. After considerable palavering he managed to make a bargain with one, and was soon comfortably seated in the stern of a small boat and was put on board the steamer.

After exchanging greetings with some of his fellow-passengers and with the ship's officers he decided that as he was feeling so well he would spend a part of the day in the engine and fire rooms. As he emerged from his state-room, clad in his overalls, he was accosted by the chief engineer, who asked if he was going to try it again below, at the same time cautioning him regarding the heat. He went on to tell the Professor that he had made arrangements with a shop on shore to have about fifteen new tubes put in the boiler which had been blown down, and that they would probably be in port until the following morning. This was cheering news, as the college man had some time before concluded that he wouldn't care if they stayed in that port for a month. As he went into the engine-room he found the first assistant and a gang of men hustling around, making adjustments and overhauling things generally. Much to his surprise he found that the engine-room was almost as warm as when the vessel was under way. It had never occurred to him that when the cylinders of a large engine become thoroughly heated it would take them such a long time to cool off.

Walking out to the fire-room, he found there a scene of confusion. The workmen from shore were busy removing the old tubes, and the din of hammering made it almost impossible to hear anything else. The

second assistant was "bossing the job," and as the shore men were working by the hour the gestures he was making indicated that he was using some vigorous language in his efforts to get as much work out of them as possible. He took time, however, to nod to the Professor and beckon to him to come over to where he was standing. During a lull in the noise he informed him that while the old tubes were being cut out and replaced he was having the boiler given a thorough cleaning. Looking through one of the furnace doors he espied a man in the back connections vigorously brushing away at the surfaces and surrounded by a heavy pall of soot. This was a part of the duties of a fireman that the Professor had never witnessed before. As he was standing there a man crawled out of one of the wing furnaces to get a breath of fresh air. By a series of acrobatic motions he finally got out and stood up alongside of the Professor. The man's appearance almost horrified the sympathetic college man. He felt convinced that he was a white man, as there was none other in the crew, but from his present appearance he certainly looked like the blackest of negroes, and the Professor felt sure that his own mother would not have recognized him. His hair, which was naturally of a reddish tinge, was now as black as ink. His ears were almost filled up with soot. His skin was covered thick with a pasty-like substance composed of soot and perspiration, and his overalls, originally blue, were now as black as his shoes. In fact, the whites of his eyes and his teeth were the only visible parts which were not of inky blackness. In spite of his evident discomfiture, he smiled and nodded to the astonished college man as if he had casually met him on deck.

"Goodness gracious, my poor man, how in the world do you stand such work?"

"Oh!" said the fireman, "it's all in getting used to

it, but, to tell you the truth, it isn't much fun, sir. I don't know but that I would rather clean the back connections than work inside," he continued. "Just look at Callahan in there," said he, pointing to one of the manhole openings.

The Professor looked through the opening, and by the flickering glare of a smoky hand lamp hung on one of the boiler braces he discerned the form of a man who was working away at cleaning the crown sheet of one of the furnaces with a wire brush. The man was simply wedged in between the furnace and the shell of the boiler, and just had sufficient room to work his arm. The Professor ventured a little closer and stuck his head inside the manhole. The sickly, warm vapor-like atmosphere inside the boiler soon caused him to withdraw his head and gasp for a breath of the pure air in the fireroom. His first impulse was to rush on deck and protest to his brother that it was nothing less than downright cruelty to compel men to work in such a place. While considering this move his attention was attracted by a pair of shoes being thrust out of the manhole, which were soon followed by a man's legs, which, after being waved around in the fireroom, gradually elongated until after a final effort the whole of the man's body emerged from the narrow opening. The man proved to be Callahan, who, after drawing in a deep breath of cool air, smiled and said, "Good morning, sir; I thought I would come out and get a spell, as that is pretty hard work in there."

"Hard work!" said the Professor; "I don't see how you live, let alone do any work, in such an infernal place as that."

"Oh!" replied Callahan, "that isn't so bad; if we can get a whiff of fresh air occasionally and a few minutes' rest, I don't mind it so much."

The second assistant, overhearing the Professor's remarks, said to him:

"That's one part of the business that you don't learn in books, but it is something we practical men all have to go through with. I've done my share of it, and, in fact, I'll have to go all through this boiler today to see that these fellows have cleaned it properly."

The Professor said he was glad that he did not have to do it, "for," said he, "one day of that kind of work for me and there would be a vacancy in a certain college faculty that I know of."

"It isn't so bad as all that," replied the officer, "but it is something that has to be done, and we generally try to make the best of it."

Callahan had now finished his spell and crawled back through the manhole into the boiler, from which the faint sound of a man whistling could be heard as he resumed his work. The Professor again looked in and this time saw the fireman rubbing the crown sheet with a handful of old bagging. This, the assistant explained, was soaked in kerosene oil, and was for the purpose of removing such of the greasy deposits which had not been taken off by the wire brush.

"Isn't it dangerous to use kerosene oil around that old hand lamp?" inquired the Professor.

"Yes, I suppose so, but then the men have to be careful," said the engineer.

"What a horrible thing it would be if that man's oily clothing should catch fire in that cramped space," said the college man. "Why he would be literally roasted alive before he could get out."

"That is one of the pleasant things that goes with the job," said the assistant; "but how are you going to prevent such dangers?"

To this the Professor replied that he thought some-

thing ought to be done to make such work less dangerous and uncomfortable to the poor men who had it to do, and that he would try to think of some scheme to help them. Upon inquiry he learned from the engineer that there were six men cleaning the inside of the boiler, and that it would probably take them all day to complete the job. The interior had been found to be fairly clean, except for a thin coating of grease and scale on the heating surfaces and on the shell at the water line. When it got very dirty, he was informed that it was customary to boil it out with soda and concentrated lye and then give it a thorough blowing out through the surface blow.

The Professor said, "Of course you only clean by hand such portions of the heating surfaces as can be gotten at, but how do you clean the tubes which are inside of the outside rows?"

"We don't clean them at all," replied the assistant, "except what cleaning they get by the boiling-out process, and that, I find, does not remove the grease and scale from those tubes."

"As those tubes constitute more than three-fourths of the heating surface," said the Professor, "it seems to me that some attempt should be made to get at them for cleaning purposes."

"Well the only way that I know of is to cut them out and put in new tubes," replied the engineer.

As the Professor felt that he was in the way, and taking up too much of the engineer's time, he determined to go up on deck and to come down in the fireroom again after luncheon. After this function was over he called the subject of boiler cleaning to his brother's attention, and remarked that something ought to be done to make the work a little less irksome. To this the chief replied that he was ready for suggestions.

"Well," continued the theoretical brother, "I have thought the matter over, and my ideas may seen impractical to you, but, for one thing, I would not let a man go inside a boiler with one of those miserable hand lamps. You have steam on the boilers, and a dynamo that is not in use. You certainly ought to have a half-dozen portable hand lamps and sufficient insulated wire to reach to any part of the boiler. With electric lights the men would not be in danger of having their clothes catch fire, and they would not have to breath the horrible smoke from burning lard oil in the lamps. The air in a boiler recently blown down is certainly foul enough without the addition of so much of this sickly smoke."

"Another thing is, that you have a whole lot of electric fans on board here which are not now in use. What is to prevent you from connecting three or four of them up so as to blow fresh air into the lower manholes so as to create a current of air through the inside of the boiler and thus get rid of a great deal of that foul vapor that collects there? Of course I know that you may think these ideas are a little 'old maidish,' but I feel convinced that a few little attentions like these to the comfort of the workingmen would be more than compensated for by the increased amount of work that would be accomplished."

"I think that it is also possible to devise a rotary wire brush that could be operated by a small electric motor, and manipulated by a man inside of the boiler. In that way the crown sheets could be cleaned in a third of the time now taken up on cleaning them by hand. I also understand that an electric brush has recently been patented for cleaning in between the tubes, which cannot be gotten at by hand. This motor rests on a moving carriage which is slid along

on top of the tubes, and which operates a long steel wire brush which is so shaped as to fit in between the adjacent rows of tubes in such a manner as to clean the entire surface."

The chief, after giving the suggestions considerable thought, remarked that he thought some of his brother's ideas were good ones, and that the next time they cleaned a boiler he would try the electric lights and the fans.

"It won't cost anything to speak of, and it might do some good."

The Professor sat around under the awnings watching the unloading of freight, until about four in the afternoon, when he decided to take another look into the fireroom. It was still quite warm down below, as there was very little breeze blowing, and consequently but little air was driven down the ventilators. Much to his surprise he found that all of the damaged tubes had been drawn out, and over half of the new ones had been put in their places. He took occasion to examine some of the old tubes which had been cut out, and found that most of them had leaked on account of pits, which had eaten clear through the metal.

He found upon inquiry that but little of the old zincs were found inside of the boiler when it was opened up, which satisfied him that the damage to the tubes was occasioned by neglect in looking after the zincs. Although no baskets were to be had for holding the new zincs, at that time, he was much pleased to learn that the second assistant had put in a liberal amount of new zinc plates, and that they had been connected to the braces in the manner that he had described. The second assistant inquired of him as to how much zinc he thought ought to be put in the boiler. To this the Professor replied that it was

very hard to tell, as it depended largely upon experience. He suggested, however, that it would not be far out of the way if they used about a ratio of five pounds of zinc for each square foot of grate surface in the boiler.

The men had finished cleaning the interior of the boiler and had gone on deck to wash up. The manhole plates had been replaced and everything was in readiness to start fires as soon as the boiler-makers finished putting in the remainder of the new tubes. As it was impossible to do this before eight o'clock in the evening, the Professor decided that he would spend another evening on shore. As he walked through the engine room on his way up he could not help noticing how neat and clean everything looked when contrasted to the appearance of things on the previous day. The floor plates had been thoroughly cleaned, and all the brass work about the engine was shining. Seated on a box in a corner was Barney, with his face buried in his hands. Upon being asked if he was ill, the oiler replied, "No, sir, I'm not exactly sick, but I'm on the *sthool* of *repintance*. I wint ashore lasht night and drank a whole lot of that dago booze they have here, and my head has felt as if there was a wather hammer in it all day."

The Professor smiled and said that it must have been an alcohol hammer he had felt.

"You know, Barney," said he, "that the best way to stop a water hammer is to shut down on the throttle, so the best way for you to prevent these headaches is to throttle your thirst when you go ashore."

"Right you are, sir!" groaned poor old Barney.

After a few expressions of sympathy for the oiler, the kind-hearted Professor went to his stateroom

and prepared to spend another evening on shore before the ship sailed.

CHAPTER IX.

HOW TO USE INDICATORS.

In company with several of the passengers the Professor spent another delightful evening on shore, but as the ship was to sail early the following morning he reluctantly had to forego the pleasures of another comfortable night's sleep at the hotel. As they were rowed out to the ship in a shore boat, the Professor was much impressed with the beauties of the harbor at night. The sky was brilliant with innumerable stars and for the first time in his life he gazed upon the Southern Cross which was pointed out to him. The boat left a golden wake behind her, and each stroke of the oars seemed to make a swirling pool of molten gold, so pronounced was the phosphorescence of the sea water. The faint outline of the steamer could be discerned with the electric lights gleaming through her air ports. From several other vessels in the harbor faint sounds of singing could be heard, and the distant strains of an accordion, the sailor's favorite musical instrument, were wafted over the still waters. Arriving on board he found the Chief Engineer, who informed him that the repairs to the boiler would soon be completed and that they would sail at about five in the morning. When he awoke on the following morning he found that the ship was rolling around in the same old way, and he was brought to a realization that he was once more at sea and subject to the many vicissitudes of the deep. After he had finished his breakfast he strolled out on deck, where his attention was attracted to a group of the passengers standing near the rail engaged in an animated conversation. Listening a few moments to the trend of the remarks, he was surprised to learn that the subject under debate was whether the flying fish,

which were at that time very numerous about the ship, actually flew or not. One dogmatic individual took the side that they did not fly at all, and that they simply "soared," as he expressed it. The Professor, after apologizing for breaking into the conversation, asked how it was possible for the small area of the fish's fins to support the weight of the body if the fish simply soared. Continuing, he remarked that the question whether these fish actually fly or not had been discussed at a meeting of a scientific society about twenty years ago. Several of the so-called scientists argued that it was impossible for the creatures to propel themselves through the air owing to the small size of the muscles of the pectoral fins. Their theories were completely routed by a paper read by an engineer officer of the U. S. Navy, wherein by mathematical calculations he demonstrated that it was not only possible but that they actually did fly, as it was shown clearly that "soaring" was an impossibility. This statement led one of the passengers to remark that marine engineers must be very intelligent men to discuss such subjects. To this the Professor replied that the profession of marine engineering was essentially one wherein common sense predominated, and that in his experience he had found that men educated and trained in this branch were enabled to grasp almost any subject and deal with it in an intelligent manner. The diversified problems which present themselves almost daily to sea-going engineers, and the celerity and originality with which they must be met, constitute a mental training which, said he, is calculated to prepare men for almost any walk in life. Continuing, he remarked that some of the most eminent men in the entire engineering profession are those who have served some time at sea. The Professor then cited a number of instances where former marine engineers had attained great prominence in various pursuits on shore. By the time the college man had fin-

ished his discourse, that group of passengers, at least, had a much higher opinion of the toilers below.

In the afternoon he was joined by the Chief Engineer, and the conversation drifted to engineering subjects. The Professor asked him how often they took indicator cards from the engine. "Well," replied the Chief, "I don't have them taken very often, as it is too much bother, and besides that I don't see what particular good it does anyhow." "You are mistaken there," replied the college man, "for in my opinion at least, one set should be taken every day. In that way only can you keep track of what your engine is doing. It is not so important to take them for determination of the horse power developed, but you can determine how your valves are set, and whether the valves and pistons are leaking. Of course there are a number of scientific facts to be determined from indicator cards, but for your purposes on board ship it is well to take at least one set every day, for future reference, if for nothing else. He then inquired if the ship was furnished with a set of indicators and the necessary gear for working them. He was informed that there was only one indicator on board, but that the gear was fitted to each of the three cylinders.

"Only one indicator," said the Professor. "Then I don't blame you much for not wanting to take indicator cards, as I have had some experience myself in shifting springs on a hot indicator. I don't see why the owners don't furnish you with a set of three indicators, as the additional first cost is very little when compared with the trouble it gives the engineers in taking a set of cards with a single indicator, not to mention the fact that it is impossible to accurately compute the horse power, unless the cards are all taken at practically the same time."

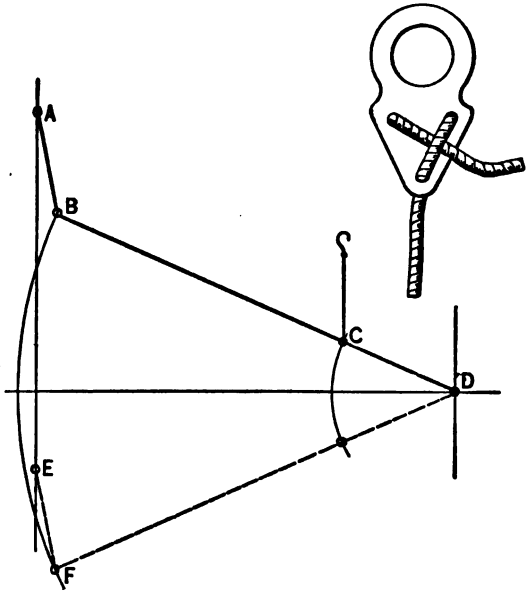
Continuing, he said: "I haven't seen your indicator gear, but if I was a betting man I would wager even

money that the gear is not fitted correctly." "I don't know about that from your standpoint," replied the Chief, "but our gear is fitted in about the same manner as I have seen it fitted to many other steamers." Just to satisfy his curiosity the Professor walked down below in the engine room, and at one glance he discerned that the indicator gear was fitted, in common with a great many other merchant vessels, in a wrong manner. The reducing motion was, of course, taken off the cross-heads through the means of a short link, and an indicator arm pivoted on a stud screwed into the back column, the motion being transmitted to the indicator by means of a string looped over a pin screwed into the arm about 6 inches from the pivot. Returning to the deck he informed his brother that the gear was fitted wrong, just as he had expected to find it. To a request from the Chief that he would like to have it explained to him wherein the gear was not accurate, his brother replied as follows:

"The most essential thing about an indicator gear is to have the motion of the revolving barrel exactly coincident with the stroke of the piston. That is, every point in the length of the card must correspond exactly to the similar point in the stroke of the piston, or otherwise you will not have an exact representation of the steam and expansion lines on your card. While it is true that for practical purposes a slight discrepancy does not make a great deal of difference, as long as you take indicator cards it is better to have them absolutely correct than to have even the slightest doubt concerning their accuracy. Now," said the Professor, as he pulled out a scribbling pad from his pocket, "here is the manner in which your gear is arranged.

"A is the point on the cross-head of the attachment of the link A B, and B D is the indicator arm. At the point C the pin to which the indicator cord is fastened is screwed into the arm. Now, as you will see, the

point A travels up and down on the straight line A E, representing the stroke of the piston. The point B travels on the arc of a circle which has D as its center.

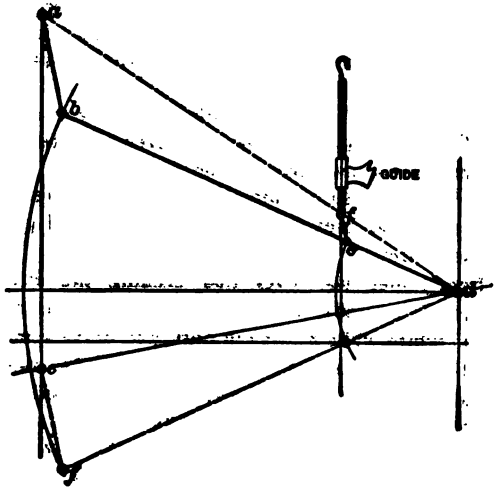


INCORRECT FORM OF GEAR AND A HANDY KNOT FOR STRING

As you can easily see, this point B, while traveling on this arc, does not cover the same distance in a vertical direction as does the point A, which is going up and down in a straight line. Now the same can be said of the point C, which also travels on the arc of a circle, and hence does not impart a motion to the indicator barrel accurately coincident with the stroke of the piston.

"Here is how this difficulty can be overcome, and is the way that all indicator motions should be arranged:

"By fitting a small link to the indicator rod at the point C, and connecting the other end of it to a vertical rod guided as I have shown it, you will find that a correct motion is given to the indicator barrel. The length of the small link *c f* should be such that the point *f* is at the intersection of the line *a d* with the vertical line



A CORRECT FORM OF GEAR

through the center of the rod, and hence is proportional to it. The links *a b* and *f c* will then be parallel, and as a result the point *f* will always have a precisely similar motion to the point *a*; that is, the barrel on the indicator will be given a motion in a constant proportion to that of the piston, which accomplishes the desired object."

"I can see the point of your argument," said the Chief Engineer, "but I really don't see that it makes much difference practically, only as you say, if we are going to have indicator gearing fitted, it might just as well be correct."

"Another good feature about this kind of a rig," continued the Professor, "is to have these vertical rods run up to about two feet below the indicators, and leave the top ends forged into the shape of a hook. The strings can then be attached to these hooks by the man using the indicator, without the bother of crawling down below and performing sleight-of-hand tricks every time he tries to loop the string over the pin on the indicator arm."

"By the way," said the Professor, "if you don't object I will go down below this evening after it gets cool and take a few cards off the engine."

His brother assured him that he would be very much pleased to have him do so, and that he would go down and help him.

After dinner was over that evening the Professor donned his overalls, which he had taken pains to have washed white while he was in port, and bravely marched into the engine room, not forgetful of his past experiences there. He was agreeably surprised to find that after sundown it was not quite so warm as it had been, and that the breeze coming down the ventilators kept the temperature of the engine room down to a moderate point. The Chief sung out for Barney to get the indicator out of the store room. After considerable delay he managed to find it, all covered over with dust in an out of the way corner. Upon opening the box the Professor found, much to his disgust, that when last used the spring had not been removed and that the interior of the instrument had not been properly dried out and oiled. As a result the spring was quite badly

rusted, sufficiently so to make it unreliable in recording pressures. The Chief inquired if there was not a rule governing the strength of springs to be used in indicators. To this the college man said that he knew of no rule applicable to all cases, but that in his opinion, for a triple expansion engine using a boiler pressure of 160 pounds per square inch, it would be a good proportion to use springs of 80, 40 and 20 pounds' strength respectively in each of the three cylinders. He further said that it was a good rule to select springs which would not give cards over two inches in maximum height, and that it was also a good idea to so arrange the reducing motion as to give cards of a uniform length of four inches. He also said that a 20 pound spring in the low pressure indicator would not give a card much more than one inch in height, but it was better to use a spring of that tension in order to prevent the pronounced vibration which would necessarily result from the use of a lighter spring.

Selecting the proper spring for a high pressure card, he fitted it in place and oiled the steam cylinder with some cylinder oil, remarking as he did so that it would be much better to use a lighter grade of oil, such as is furnished by the manufacturers with the instrument. A new piece of string was cut off the hank in the box and Barney was directed to loop it over the pin on the indicator arm, which he succeeded in doing after a number of efforts. The Chief gave the indicator pipes a good blowing out and then secured the instrument in place. The next thing was to adjust the string so as to give the barrel an even stroke at the ends. After making a number of new slip-knots this was finally accomplished. The Professor explained to his brother that it was a good scheme to have a small flat piece of brass with three holes bored in it so that the length of

string could be more readily adjusted. To illustrate his remarks he made the sketch shown on page 72.

The Chief promised to have one made for him, and remarked that he had seen such a device before, and that it was all right. The Professor next sharpened the pencil at the end of the indicator lever, saying as he did so that he preferred to use chemically prepared indicator cards upon which a black mark could be made with a sharp pointed brass screw instead of a lead pencil. Everything being ready the Professor drew the atmospheric line, calling his brother's attention to the fact that during this operation the lever on the indicator cock should always be so placed as to connect the interior of the steam cylinder with the atmosphere, as otherwise the leakage through the cock might affect the height of the line. After very dexterously taking several cards the Professor said that as it was getting rather late in the evening he would "turn in," but promised that on the next day he would have something further to say about the indicator cards themselves.

CHAPTER X.

SIMPLE EXPLANATION OF THE INDICATOR.

On the following day the Professor spent the greater part of the morning lolling about under the awnings and in reading. The fact of the matter was that the prevailing temperature was having its effect on him, and he had reached that stage where he was losing his ambition to keep employed at something useful. At about ten o'clock he joined the 1st Officer on the bridge, and watched him taking a sight with the sextant, or "shooting the sun," as the officer expressed it. Although the Professor had never actually taken a sight he was more or less familiar with the theory of navigation and very readily followed the officer's calculations for a time sight. The air of mystery and superiority which the deck officer assumed during this operation was very amusing to the college man, for the calculations were so simplified by reference tables that anyone with even a rudimentary knowledge of trigonometry could easily learn as much navigation as the deck officer possessed, in a very few lessons. In fact he quite astonished the navigator by pointing out to him several methods of shortening his calculations, which he reluctantly acknowledged were improvements. The Chief Engineer, who happened along at that time, seemed also somewhat agreeably surprised that his younger brother possessed so much knowledge of a subject in which he himself was entirely lacking, although he had spent many years at sea.

The Professor explained to him that any man educated in a technical school could easily grasp such subjects, as his mathematical training fitted him for just

such work. To this the Chief replied that a technical education was undoubtedly a good thing to have, but how, said he, can a young man who has to hustle for a living from the time he is fourteen years old, ever expect to get a college education? The Professor remarked that he was glad to have that subject brought up, and went on to state that to obtain an education in the engineering profession it was not absolutely necessary to attend a college.

"It does not make a particle of difference whether a young man is a graduate of a technical school or not; it is what he can do that determines his standing and fixes his salary. There are just as competent men in the profession to-day who obtained their education by their own efforts, as there are who have graduated from colleges. Of course, everything else being equal," he continued, "the college man has the advantage at the start, but in actual work the man who uses his brains and skill to the best advantage in his employer's interest, will eventually go to the front whether he is a graduate or not. In this connection the Chief asked his brother what his opinion was of the various correspondence schools which are now so extensively advertised. To this interrogatory the Professor replied that he considered them as excellent institutions.

"Why," said he, "one of my colleagues at the university where I am employed originated the correspondence instruction idea, and I am very much pleased to see how successful it has proven to be. In this way hundreds of young men are being greatly aided in their efforts to obtain an education. As the attainment of that end is entirely due to a man's own efforts, there seems to me to be no reason why any young man, and especially oilers and junior engineers on board ship who are ambitious to succeed in their profession, should not be greatly helped by joining one of these schools.

Of course," said he, "I am a firm believer that young men with the necessary means should attend technical schools, but if they are not able to do so, the next best procedure is to get as much help as they can in this modern method. They can then earn their own living, and spend part of their spare time in studying. I understand," he continued, "that there are numerous cases where young engineers have been materially advanced in their business through the help of a course of studies as mapped out by some of these correspondence schools."

After luncheon that day the college man stretched himself out in an easy chair and, like a good many of the passengers, he enjoyed a siesta. When he awoke he was approached by the 1st Assistant, who remarked that he was glad to see him enjoying himself.

"Yes, I am getting quite lazy," said the Professor, "and if the engineer's crew all felt as I do I am afraid that the ship would come to a standstill until all hands had taken a nap."

The Assistant reminded him of his promise to explain something more about indicator cards.

"Oh, yes, so I did," said the man of figures. "If you will get me those cards I took last evening and a scribbling pad I will see what I can do with the subject."

The Assistant promptly went down in the engine room, and after obtaining the desired articles, brought them up on deck. He was soon joined by the Chief, who remarked that as he was a little shy on the subject he would like to hear what his brother had to say.

Taking up the subject the Professor stated that he supposed they were quite familiar with indicator cards, and apologized in advance if he should attempt to explain anything which they already knew.

"Now that we have taken a set of cards from the high pressure cylinder, it would, of course, be well if we had several sets from each of the other cylinders, but for purposes of illustration the high pressure cards will do very well. As you probably know, an ideal card should look something like this: (See Fig 1.)

"On this card I will mark the names of the different lines and points, which it is always well to remember when discussing this subject. As you can easily see, the actual cards which we took last evening differ con-

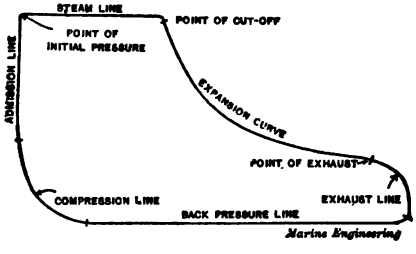


FIG. 1.

siderably from the card which I have sketched, due to many causes. For instance, on the ideal card the admission line is shown very nearly perpendicular, and, in fact, it should be exactly so. If it inclined inward, and the indicator was correctly adjusted, you could feel positive that the valve was so set that the steam was admitted too late. If, on the other hand, the admission line was inclined outward, the valve would evidently be admitting the steam too soon.

"The greatest discrepancy is liable to exist in the expansion curve. This curve follows nearly the shape of a hyperbola. It is often found, however, that the terminal pressure at the end of this curve is higher than it would be with the usual law of expansion. This

is largely due to the fact that almost all steam valves leak steam into the cylinder after the point of cut-off has been reached.

"Sometimes, too, it will be found that the curve runs lower than might be expected. This state of affairs is due generally to the fact that the engine piston and the exhaust valve leak. At times cards are obtained wherein this curve is apparently correct, but it is not always safe to assume that because of that effect the valves and piston are tight, as the leakage through both may be just sufficient to compensate each other. You may have observed that the expansion curve is sometimes wavy; this condition is generally caused by water in the indicator cylinder, or to an excessive amount of vibration of the instrument. There are numerous other defects that I might point out to you in connection with indicator cards, but in general it should be the aim in designing an engine, and in adjusting the valve gear, etc., to give a card with the following general features:

"1. The steam line should be as nearly parallel to the atmospheric line as possible, and it should be nearly as high as the line drawn to the scale and representing the pressure in the boiler. This result shows that the steam pipe is sufficiently large; that there is no undue friction in the stop and throttle valves and main steam pipe; also that the steam ports and valve openings are of sufficient size.

"2. The expansion curve should be nearly hyperbolic, showing generally that the valves and piston are tight.

"3. The admission line should be nearly perpendicular to the atmospheric line, showing that the steam is admitted to the cylinder at exactly the right time.

"4. The back pressure line should be parallel to the

atmospheric line, showing that there is a sufficient opening of the exhaust valve.

"5. The point of cut-off, point of exhaust opening and point of exhaust closing should theoretically be clearly defined, but in practice, owing to the gradual opening or closing of a slide valve, they are generally represented by curved lines."

At the conclusion of this part of the Professor's dissertation he looked up and somewhat to his chagrin saw the Chief with his eyes closed and slightly nodding his head. Upon being accused of sleeping, he quite indignantly denied the charge and said that he was simply trying to memorize what the Professor was saying. Considering the closeness of the afternoon the Professor felt inclined to doubt his brother's assertion.

"I wouldn't blame you much if you were asleep," he continued, "as this is a somewhat dry subject. Now if you will keep your eyes open for a few moments I will try to show you something about working up cards to determine the power developed by an engine. The first thing I want to impress on you is to clearly understand the term 'power'. Many people use the terms 'work' and 'power' as synonymous. As a matter of fact they do not have the same meaning at all. For instance, if you carry a weight of 10 lbs. up a flight of stairs 20 feet high you have performed work to the amount of 200 foot pounds. That is, work consists of two elements only—force and distance.

"To determine the 'power' you used in carrying up that weight you must take into consideration the time you spent in going up the stairs. That is, power consists of three elements—force, distance and time. In the early days of the steam engine, it was of course found necessary to establish a method of stating the

power developed. The horse being one of the most useful and universal beasts of burden, the engineers of that day naturally based their comparisons of the power of engines on that of horses. Accordingly a series of experiments were made with some powerful London dray horses, and it was determined that the average power of these horses was equivalent to lifting 1,000 pounds through a height of 33 feet in 1 minute, or 33,000 foot-pounds per minute.

"This was then adopted as the unit of power for the steam engine. It may interest you to know, however, that the average horse cannot raise a weight of 1,000 pounds a distance of more than 27 feet in a minute. That is, they can only develop a little over 80 per cent. of the so-called horse power. Now then, to find the power developed by an engine, we must determine just three elements. The time and distance are easily ascertained by noting the number of revolutions made by the engine in one minute. The actual distance traveled by the piston is of course equal to twice the number of revolutions, as it goes up and down in one turn of the engine. Thus your engine here has a stroke of 36 inches, and is now making about 110 revolutions per minute.

"Remembering that the distance must be expressed in feet, you see that the piston travels 3 feet down and 3 feet up, or 6 feet in one revolution and 660 feet in one minute at the speed of 110 revolutions. This 660 feet is known as the 'piston speed,' and, by the way, that is rather slow for a modern engine, as nowadays a piston speed of 900 to 1,000 feet ought to be obtained on all first-class passenger vessels.

"The other element, 'force,' is somewhat more difficult to determine, and here is where we use the indicator card. As you know, the spring of an indicator is so

proportioned that the height of the steam line and the expansion curve show at any point the pressure of the steam on the piston, when measured by a scale proportioned to the spring. As this varies at nearly every point on these lines it is necessary to obtain the average height and consequently the average pressure on the piston during the entire stroke. There are several methods for ascertaining this average height. The best method is by the use of an instrument known as a planimeter. This is an instrument such that by running a pointer all around the card the exact area inclosed can be read from a cylindrical scale, with a

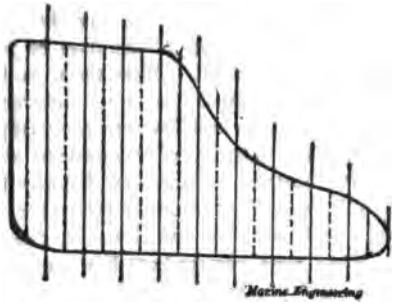


FIG. 2.

vernier attachment. It is usual to take the average of two or three readings of this scale in order to minimize the chance of error. Knowing the area of the irregular figure, and the length, the average height is readily determined by dividing the area by the length. If you do not happen to have one of these instruments the average height may be approximately determined by the following method: Divide the diagram, as shown in Fig. 2, into any number of equal parts, say ten for convenience, by drawing lines perpendicular to the atmospheric line. Then subdivide each one of these

parts into two equal parts, as shown by the dotted lines. Measure each dotted line with a scale graduated to correspond to the spring used in the indicator. Add together the lengths of these dotted lines and divide by 10, and the quotient will be the average height, or the mean effective pressure.

"A convenient method of measuring these lengths is to take a strip of paper and mark off on its edge each length, one following the other. The sum of all the lengths or ordinates, as they are called, can therefore be determined by simply measuring the distance between the extreme points with the scale used. Knowing the average pressure exerted on the piston during its entire stroke, it is only necessary to multiply it by the area of the piston expressed in square inches to determine the third element of 'force' for the calculation of the power.

"In estimating the power, you must not lose sight of the fact that as the piston rod comes through the bottom of the piston, an allowance must be made for its area. Thus the high pressure cylinder of this engine is 30 inches in diameter, and the piston rod is 5 inches in diameter. The area of 30 inches diameter is 706.86 square inches. This area is correct for calculating the power during the down stroke; but on the up stroke the rod must be taken into account. Thus the area of a 5-inch circle is 19.63 square inches and 706.86 — 19.63 = 687.23, the area to be used for calculating the power developed on the up stroke. It is usual as a matter of convenience to take half the area of the rod from the total area of the cylinder, and to use this area for calculating the power developed in one revolution, or two strokes. Thus ½ of 19.63 = 9.86 and 706.86 — 9.86 = 697.00 square inches in the area to be used.

"The old formula of P. L. A. N. ÷ 33,000 is very convenient to memorize, but it is too often used without

knowing its meaning, and I hope that I have made it clear to you. Thus you will see that the factors P and A are necessary for determining the element force; N and L determine the elements of time and distance. I know that I have gone over a great deal of matter that is already familiar to you, but it won't do any harm for you to review it, and I hope that I have brought out some new ideas of the subject for you."

The Chief Engineer, who had kept awake during the latter part of his brother's talk, thanked him for what he had explained to them, and said that he had been much interested. The 1st Assistant said the same thing, so the Professor did not think that his time had been entirely wasted, although he felt doubtful as to whether he had imparted any new information to his listeners.

CHAPTER XI.

OVERHAULING THE MACHINERY.

The days were now passing rapidly. The weather was so hot that the Professor was not in the least anxious to gather any more practical information by going below in the engine and fire rooms, so he spent most of his time during the day lolling around on deck, reading or writing. Occasionally he would talk with groups of his fellow-passengers, and, as a rule, he would interest them greatly, as he was found to be well informed on almost any subject that would arise in the course of the conversation. One of the lady passengers, who had evidently seen at least forty winters, not to mention how many summers, upon hearing that the learned man was a bachelor, became particularly interested in him, and was one of his most attentive listeners whenever he would talk. No matter whom he was addressing, the sprightly spinster would in some way manage to draw her chair close up to where he was sitting. Her attentions became so marked that they furnished a continuous source of amusement to the other passengers. As it gradually dawned upon the Professor that he was the object of her adoration, and not caring particularly for such attentions, he became quite shy and managed to stow himself away in places somewhat inaccessible to his admirer. On several occasions he was inveigled into playing an innocent game of euchre, and one evening he was invited by several sportily inclined young men to take a hand in a game of poker. This he declined with thanks, for, as Barney declared, "He was not the aisy mark that he looked."

Para was to be the next calling place, and speculation

was rife as to what time the ship would get there. The poker-playing contingent got up the usual pool as to the time the ship would anchor, and the Professor came up with his five dollars in short order, thus showing that he had some sporting proclivities for a game where he would have an equal chance with the others.

One evening when the ship was nearing her destination the sky in the northwest became clouded, and, as the barometer took a sudden fall, the officers began to make preparations for a blow. The day had been calm and sultry, and the atmosphere at six o'clock was almost stifling. A portentous feeling pervaded the ship, and the Professor, in common with the other passengers, felt as if something dreadful were about to happen. The heavy clouds now almost obscured the sky, and over the starboard quarter they seemed of almost inky blackness. All movable articles about the deck were secured, and the captain and first officers were going around and examining all fastenings and lashings to see that everything was secure. Brilliant flashes of lightning illumined the sky at intervals, to be shortly followed by the deep rumblings of distant thunder. The Professor seemed awe-stricken as he stood by the rail and scanned the approaching storm. A light puff of cool wind struck his face, and at the same moment some one shouted, "There she comes." About half a mile away a dense wall of vapor could be seen whirling toward them in the semi-darkness. So rapidly was it approaching that before the Professor could make up his mind to run for shelter the tropical squall, for such it was, had struck the ship with its full fury. The ship was thrown nearly on her beam ends by the force of the gale, and it was all the poor college man could do to crawl on his hands and knees to his state-room door. Before he could open the door the rain came, and in almost an instant he was drenched to the skin. So

heavy was the torrent accompanying the blow that the Professor felt as if a regiment of men were dashing buckets of water over him. The screeching of the gale, the roar of the downpouring rain, the almost incessant and blinding flashes of lightning, together with the terrific thunder, spread terror to his heart. It is safe to say that he would have willingly given up a year's salary to be on *terra firma* at that time. For over an hour the gale continued with unabated fury, and the terror-stricken man hung on and hoped. It was rumored among the crew, after the gale was all over, that he had spent the whole time on his knees praying. However that may be, the storm finally blew over, leaving a cool breeze and a delightful atmosphere, which everybody enjoyed to their utmost. Luckily not even a rope yarn had parted, so the ship proceeded on her voyage none the worse for her encounter with the short-lived storm. The chief engineer informed his brother that such squalls were of frequent occurrence in those latitudes, which information was not relished very keenly by the Professor, who had not fully recovered his equanimity from the trying ordeal which he had just been through.

The ship finally entered the region "where rolls the mighty Amazon," and in due time came to anchor off Para in Brazil. Upon looking over the pool which had been formed, it was discovered that the Professor's guess as to the time of anchorage was within fifteen minutes of the actual moment that the anchor was let go. The money, amounting to fifty dollars, was handed over to him at once, and he was the subject of congratulations from all concerned. He was naturally quite elated at his success as a guesser, but he immediately turned over the money to his brother, the chief, and requested him to divide it up equally among the firemen and coal passers, saying, as he did so, that they were the men aboard that ship who most deserved it.

The anchor had not been down long before the Professor and a number of the other passengers went ashore to see the sights. They did not find Para so attractive as their last stopping place, however, and, with one or two exceptions, all had returned by dinner time that evening. The captain told the Professor that, as there was so much freight to unload, the ship would remain in port for at least two days. The chief engineer, therefore, decided to make some necessary adjustments in the various journals, as the engine was thumping quite noticeably the day or two before they arrived.

The following day the Professor was feeling a little more ambitious than he had at sea, and, thinking that the engine room must be a little cooler than when the ship was under way, he determined to spend a few hours below. As all the men, with the exception of the water tenders, had had all night in, he found them all turned-to either in the fire room or engine room. The high-pressure crank pin had already been stripped, and the first assistant, with the help of old Barney, was busy scraping away at the brasses. The white metal was in fairly good shape, but the pin was bearing a little too much on the sides of the brasses. This was being eased off, and, after trying the brass on the pin two or three times and scraping down the high spots, it was, in the opinion of the officer, fit to put back in place. The Professor was an interested observer of the various operations of scraping, putting in leads, setting up on the bolts, etc. When the brasses were slacked back and the leads removed, he noticed that the first assistant used an ordinary wire gauge to try the thickness of the leads at different points. The Professor suggested that it would be more reliable if he would use a micrometer caliper for that purpose, stating that the leads were so soft that they could be squeezed into notches below their actual thickness. To an inquiry as to what be-

came of the leads after they were taken, the first assistant replied that he usually put them away in the engine room desk. The Professor then suggested that it would be a good idea to make a sort of scrap book out of brown wrapping paper and have a separate page for each journal. Then, by cutting three slits in the leaf for the pin or bearing in question, the lead could be slipped in place, and the position of the lead and the date it was taken could be written under it. He also suggested that the different thicknesses, expressed in thousandths of an inch from micrometer readings, could be marked opposite the points measured. By this method, he said, you can keep a continuous record of the adjustments on each bearing, and know at a glance just at what time the last adjustment was made and to what thickness the bearing had been set. The first assistant replied that he considered the college man's suggestion a good scheme and that he would get up such a book at once. After the high-pressure pin had apparently been properly adjusted, he noticed old Barney take a pinch bar, and, getting a nip between the side of the brass and the crank web, he gave it a sudden jerk, whereat the brasses gave a chug up against the after crank web.

"Now I know she's all right," said Barney. "I don't take much stock in them Mike Romets, or whatever it is you call 'em, but when you can move her with a bar without busting a suspender, she's all right."

The Professor was quite amused at Barney's philosophy, and concluded that for practical methods the old Irishman evidently knew his business. After they had finished with the high-pressure pin, they commenced preparations to raise the cap on the forward main bearing. While this was going on the Professor walked over toward the feed tank, where he saw a man removing a lot of dirty, greasy excelsior. In answer to a question, the chief, who happened to come around at that time,

replied that the excelsior had not been removed since they left New York. To this the Professor remarked that, so far as filtering was concerned, the tank had not been of any service after the first three days out. The chief replied that he supposed that it had not, but informed his brother that the filtering material was so arranged that it was difficult to renew it while the air pump was in operation. The Professor suggested that it would be well to put it in bags or other compact form so that it could be pulled out easily. Continuing, he said that unless the discharge water was kept as cold as possible this form of filter tank was of comparatively little use, as the particles of oil in the water will not congeal and settle on the filtering material if the water is kept at a temperature much over 80 or 90 degrees.

"Of course," said he, "as you have no feed-water heater here, you naturally try to keep the hot well at as high a temperature as possible, consistent with a good vacuum. That is only an additional reason why a feed-water heater should be fitted on every vessel." Continuing, he said that he did not know of any very efficient filter on the market at the present time.

"I have had an idea for a long time," said he, "that eventually some one will devise a filter wherein the particles of oil will be removed from the feed water by centrifugal action similar to the manner in which they separate cream from milk in large creameries or cheese factories. This separation of the oil from feed water is one of the most important problems before the marine engineer to-day, and especially so since the water-tube boiler is so rapidly coming into use."

The chief agreed with him that this was a very important subject, and he said that he hoped some efficient device would be gotten up for the purpose.

"There is one little detail I want to call your attention to about feed tanks," said he, "and that is, if you

ever have anything to do with getting one up, don't put one of those fancy float valves over the suction to the feed pump. I had one in here and ripped the thing out the very first trip I made with it. They work all right on paper, but they are bound to hang up or get out of order just when you least expect it. It's all rot to think that you are going to pump air into the boilers if you don't have such a valve. If I had a water tender, and he couldn't tell in an instant by the action of the pump that the tank was nearly empty, I'd fire him on the dock quicker than a snowball will melt in the lower regions. Then, too, I've seen a float rigged up so as to throttle down the pump when the tank gets empty. That's another crazy scheme; it may work all right on some tugboat around a harbor, but no such contrivance for me on board a seagoing vessel. If some of these youngsters who work in a draughting room and spend a lot of their time inventing such contraptions could go to sea and try to run them they would not be so anxious to get up such labor-saving (?) devices."

The Professor replied, quite warmly, that seagoing engineers were indebted to just such young fellows as he described for many of the greatest improvements they had around marine machinery. The chief said, bluntly, that he didn't believe it, and the Professor, not caring to continue the argument, let the matter drop, but clung to his own opinion. The chief, however, continued his growling and said:

"Now if some of your smart alecks want to get up something useful, let them invent a rig that will warn the water tender when the feed tank is nearly full, so that the water will not be wasted by running over into the bilge." The Professor replied that that was a very easy proposition.

"Why," he said, "just rig up a float so that when it

rises to the top of the tank it will make an electrical connection and ring a bell in the fire room."

"There you go with your old float again," growled the chief.

As he was evidently down on floats, the Professor concluded to stop suggesting anything in that line. They walked around the engine room together, occasionally getting into an argument, and sometimes agreeing. At one stage of the conversation the Professor asked his brother why he did not have some system of painting the various parts of the machinery.

"If you want to know of a good system I will describe one for you," said the Professor. "Well," replied the brother, "your painting system may be all right, but I'm more interested in getting something to eat just at present, so let's go up to lunch and we'll talk about that afterward."

The two brothers then walked out of the engine room, and Barney, who observed the difference in their physiques and had overheard some of their arguments, remarked to one of the other oilers that "thim fellers will never get a job in a circus as Siamese twins."

CHAPTER XII.

PAINTING THE PIPE SYSTEM.

The work of overhauling and repairs was continued the following day. As the Professor had seen enough of Para in his first visit ashore, he decided to stay aboard ship and look around the engine room again. Shortly after breakfast he donned his overalls and went below. He found a gang of men still adjusting the main bearings, and others employed cleaning up about the engine room. Going over to the evaporator, he looked through the manhole plate and saw one of the firemen doubled up like a jackknife and busily engaged in knocking the scale off the spiral coils. He inquired of the first assistant if that was the usual method of removing the scale, and was answered by the counter-inquiry of:

"Certainly; how else would you do it?"

To this opening the Professor replied that it seemed to him that as the coils from their very shape must be elastic, a sudden change of temperature would have the result of loosening up the scale and make it readily removable. He suggested that if steam was turned on the coils until they were as hot as they could be made, and then cold water turned on them from a hose, the effect would be to crack the scale.

"Another way would be," he continued, "to put on the manhole plates, turn on the steam until the coils and shell were thoroughly heated, then start the feed pump up as rapidly as possible so as to cause a more rapid inflow of the cool water; or, supposing you have a vacuum on the main condenser, open up the connec-

tion from the evaporator to the condenser, and open the bottom blow valve on the evaporator. This would cause a sudden inrush of the sea water and would result in loosening the scale. In either case I think you would find that a large amount of the scale would break loose and fall to the bottom of the evaporator, and that such as did remain on the coils would drop off by tapping them with a mallet or block of wood."

These methods appeared to the first assistant to be quite feasible, and he promised the college man that the next time it became necessary to scale the evaporator he would try one of them. As the man who had been working inside the evaporator came out to have a breathing spell, the Professor took occasion to look inside, and by means of the portable electric light, which he was much pleased to observe that the man had been using, he made a careful examination of the interior. He was quite surprised to see that at about the level of the water the shell of the evaporator was badly corroded, and the vertical braces were eaten away to about half their original diameter. Upon inquiry he ascertained the fact that the evaporator had been in use for a period of only two years. The first assistant also assured him that this rapid corrosion was quite common with that type of evaporators. This led the Professor to suggest that it would be economical in the end to use evaporators made of sheet Tobin bronze; he also said that the vertical braces could be done away with by using bumped heads.

"Of course," said he, "the bronze plates would cost much more than steel plates, but they would last indefinitely."

The first assistant then informed him that the latest practice with steel evaporators was to fit a soft patch belt around the inside of the shell about 9 inches above and 9 inches below the water line. If this patch is

carefully sealed and cemented occasionally, he concluded that the life of the evaporator would be greatly prolonged. The Professor asked him if they ever experienced any trouble from foaming in the evaporator, and in reply he learned that at first much difficulty was met with from this cause, but it was finally found, after considerable experimenting, that the water should not be carried over 3 inches high from the bottom of the glass. If that amount of water was kept up steadily by carefully regulating the feed pump, foaming very rarely occurred.

The Professor saw that there were no baffle plates in the evaporator and that no dry pipe had been fitted. He suggested that a baffle plate fitted tightly around the circumference of the shell with a good-sized opening in the center would tend to prevent violent foaming.

"You may have noticed," said he, "that water boiling in an open vessel has a tendency to cling to and run up the sides, leaving the center depressed. The violent ebullition which takes place in an evaporator no doubt gives the water the same tendency, so you will see that a baffle plate would, in a manner, prevent this action. I suppose," he continued, "that you always test the water that you use for drinking purposes."

"Only by tasting it," replied the assistant.

"Well, that's a fairly good test," said the Professor, "but it is not always to be relied upon, as salt or other deleterious matter may exist in the water without its being perceptible to the taste. A sure method is to draw off a glass of the water and drop in a small quantity (four or five drops) of liquid nitrate of silver. If there is any salt in the water it can be instantly detected by the cloudy appearance caused by the chemical reaction of the silver nitrate with the sodium chloride, precipitating silver chloride. From a hygienic standpoint it is very essential that the drinking water should

be as pure as it is possible to obtain it, but for make-up feed in the boilers it is not so important, and the evaporator can therefore be forced to its utmost capacity."

The chief engineer here walked up to where the Professor and first assistant were standing, and, after greeting his brother, said: "I suppose you two have settled the evaporator question to your satisfaction."

"Not at all," replied the Professor; "we have simply agreed that neither one of us knows very much about it."

"By the way," said the chief, "what was that you started to tell me about painting when you were down here yesterday?"

"Oh," said the Professor, "I was merely going to suggest that it would be a good idea for merchant vessels to adopt some such system as is now used on all naval vessels for painting the various pipes connected with the steam machinery. For example, steam pipes are always painted white, as they are usually covered with canvas. They might be, on merchant vessels, left unpainted without departing from the system. Exhaust pipes are also painted white, but they are distinguishable from steam pipes by the flanges at the joints; those for steam supply being painted black and those for exhaust painted red."

"Now," continued the Professor, "the water pipes are all painted green." ("Well, there's some sinse in that," muttered Barney to himself.) "The edges of the flanges on delivery-pipe joints are painted red and those on the suction-pipe joints are painted black. All pipes connected with the fire service are very appropriately painted red and have red flanges. Fresh-water supply pipes are painted blue and have black flanges, and discharge pipes are blue with red flanges. Flooding, drain, and flushing pipes are all painted pink and have

pink flanges. This method, while primarily designed for convenience in tracing out the leads of the various pipe systems, is found to add materially to the appearance of the engine room. As the pipes are generally painted one color or another, the adoption of such a system on merchant vessels would not add greatly to the original cost of painting. Another good feature aboard naval vessels is the system adopted for labeling all valves, cocks, connections, etc. With the innumerable fittings of this kind that now constitute such important parts of modern steam machinery, some such system as this is not only very useful, but almost indispensable. To be sure, it is possible for a man to learn every valve and connection about a ship without their being marked, but it takes a very long time, I imagine, for him to master it. Take that manifold there, for instance; I suppose that in a couple of hours or so I could, by crawling all around the ship, lifting up floor plates, etc., find out just where each valve connected. On the other hand, how much simpler and better if the name of the compartment to which each suction valve connected was indelibly cut into the rim of the handwheel, or stamped on a brass plate secured opposite each valve on the bulkhead! Another useful indication is an arrow stamped on each handwheel, with the words 'to open,' so as to show which way to turn the wheel to open the valve. A few precautions like these tend to simplify matters about the engine room greatly, and make it possible for a new man to catch on to the lay of things without wasting a lot of time in studying them out."

The chief turned around and said: "Barney, how would you like such a system around here?"

That worthy replied: "Shure that would be too aisy; ivery granehorn that we shipped would soon know as much about things as any of us old hands."

The chief, however, admitted that there were some merits in the painting and labeling systems, as he remarked that on every trip he had a large number of new men to break in, and that frequently serious mistakes were made on account of the men not being familiar with the valves.

"Why," said he, "it was only last trip that one galoot was told to pump up the boilers, while we were at the wharf, with the auxiliary feed pump. I thought from the sound of things that something was wrong, and upon examination I found that the man had opened the bilge connection on the manifold instead of the valve connecting with the feed tank. Now, if those valves had been marked as you suggest such an incident would not have happened."

The Professor, encouraged by his brother's commendation, went on to suggest that the arrangement of tools could be systematized so as to avoid the necessity of delay in hunting them up in case of emergency. "You should have all wrenches for use around the top of the engine arranged in a neat wrench board secured to one of the bulkheads within easy reach. Each wrench should have stamped on it the purpose for which it is intended. In the lower engine room the wrenches for your main bearing bolts and crankpin bolts should be hung up in a rack convenient to the engine and each one stamped. By such arrangements the wrenches would always be in accessible places, and if they became mislaid their absence from their proper places in the racks would soon attract the attention of one of the engineers. If I were a seagoing engineer I think I would pay a great deal of attention to the tools used for overhauling, as I can readily see, from the experience I have had on this trip, that a great deal depends on having the proper tools on board ship and knowing just where to put your hands on them."

It was now about 3 o'clock in the afternoon, and, as all the overhauling was completed, preparations were being made to get under way again. In putting away the tools, etc., which were used in adjusting the bearings, the Professor noticed that the caps had evidently been lifted by two dirty old rope tackles. This led him to remark that it would be very much better to have a couple of small differential hoists for the purpose.

"It seems to me that there is too much grit and dirt hanging on to that old rope to make it advisable to use around bearings. If you use chain tackle they can be easily kept clean and you don't have to bother with making the end fast every time they are used."

"Those things are too expensive for our company to furnish," replied the chief. "The superintendent would have a fit if I asked him to buy such gear."

As the ship was to sail early in the evening, the Professor washed up and togged himself out in a clean white duck suit. As he sat out under the awnings he looked out toward the ocean and inwardly prayed that no more tropical squalls might come up during the remainder of the voyage. On the run down to Rio Janeiro the weather turned out to be very fine, and the trip was made without incident worthy of note. The ship spent about a week in that port, as it was the end of her run. The Professor spent several days ashore, and enjoyed visiting the various places of interest very much indeed. He took occasion to purchase a number of curios for his friends at home, and in doing so he would involuntarily count the number of days before he would be able to deliver them. When sailing day finally came, with a whole lot of new passengers to study and get acquainted with, there was no happier man on board than the Professor. His one object now was to get home and get as far away from a ship as possible. Had there been an intercontinental railroad

in operation at that time there is no doubt but that he would have returned by rail.

On the morning after the ship sailed the Professor did not put in an appearance at the breakfast table. When the chief missed him he went to his room and found his brother lying in his berth suffering with a high fever. Whether it was due to the water he drank on shore or to the spirits that he did not drink will never be known; but at all events the Professor was a very sick man. The ship's doctor was immediately summoned, and at first was inclined to think that he had a genuine case of yellow fever on his hands. Later developments proved that it was not that dread malady, but a severe case of malarial fever. For days the sufferer was confined to his room, and at times was delirious from the fever. Every attention was given him by the officers of the ship, and even old Barney would spend much of his time off watch in his state room, where he would alternately fan him and tell him stories to cheer up his drooping spirits. When the ship got off Hatteras the Professor had so far recovered that he was able to sit out on deck and enjoy the cool breezes which now were encountered. The thought of being so near home proved to be a better tonic than any that the doctor had given him, and by the time Sandy Hook was reached he was able to walk around without assistance.

When the vessel finally reached the wharf the Professor, now more emaciated than ever, went around and bade all the engineer's force good-by and thanked each of them for the attention they had given him. Remembering his kindness in giving them the money he had won at Para, the hearty grips given him by these lusty fellows were enough to make him wince. After he had gone they all agreed that he was, as one of them expressed it, "a domnd good fellow." The Pro-

fessor had obtained the chief's permission to take old Barney back to the college with him, where he obtained a position for the oiler as chief engineer of the steam-heating plant at a salary of $75 per month. As the Professor was so weak after his illness, his brother accompanied him home to the college town. As the term did not begin for three weeks yet, the Professor went up to a mountain resort, where he rapidly regained his health. In ruminating over his experiences on shipboard he made up his mind that the place for a theoretical man is on shore, and that practical men would be much better off if they had a little theory combined with their practical knowledge.